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GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, I.S.O., M.D., D.Sc. (CANTAB.), LL.D., F.R.S.

REPORT

ON THE

GEOLOGY OF A PORTION

OF

EASTERN ONTARIO

(To accompany Map-sheet No. 119.)

BY

R. W. ELLS, LL.D., F.R.S.C.



OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S
MOST EXCELLENT MAJESTY

1904

14-J

No. 790

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To ROBERT BELL, M.D., LL.D., F.R.S., &c.,

Acting Director, Geological Survey of Canada.

SIR,—I beg to submit herewith a report on the geology and mineral resources of the area contained in Map-sheet, No. 119, of the Quebec and Ontario series. The map has been compiled by Mr. Joseph Keele, B.A. Sc., on the scale of four miles to the inch.

I have the honour to be, Sir,

Your obedient servant,

R. W. ELLS.

GEOLOGICAL SURVEY DEPARTMENT, OTTAWA,

May 1st, 1902

REPORT

ON THE

GEOLOGY OF PORTIONS OF THE COUNTIES

OF

RENFREW, ADDINGTON, FRONTENAC, LANARK AND CARLETON

By R. W. ELLS, LL.D., F.R.S.C.

This report is the second of a series, relating to the geology of the area traversed by the Ottawa river and contiguous to it, comprising in all four map-sheets, Nos. 121, 122, 119 and 120. The first of these has already appeared, and includes a somewhat detailed description of the principal geological features and mineral localities found in the district along the lower Ottawa, east of the Gatineau river. The present report refers more especially to the area entirely south of the Ottawa, being bounded on the north by a line extending west from the vicinity of Arnprior to a point a few miles north of Clear lake in the county of Renfrew, and on the south by a line east from Sharbot lake to a point a few miles south of Smiths Falls. The western line of the sheet joins that recently finished by Drs. Barlow and Adams known as the "Haliburton sheet." It embraces an area of 3,456 square miles.

Quebec
and Ontario
map-sheet.

Area
included
in report.

The compilation of the survey has been well done by Mr. Joseph Keele, B.A.Sc., but there are certain areas difficult of access, and entirely unopened to settlement where a detailed examination can scarcely be carried out. These areas are however comparatively small, and are, as far as at present known, largely occupied by granite-gneiss, the presence of which, in large masses, forms a country generally of but little value either for agricultural or mineral resources.

Compilation.

The area included in the present report comprises a considerable portion of the county of Renfrew, with parts of Lanark, Addington

Work
previously
done.

and Carleton. Portions of the district were traversed by different officers of the Geological Survey, some years ago, and different reports have been written on the included rocks, notably by Mr. Alexander Murray and Mr. H. G. Vennor. These will be referred to in the chapter on the crystalline rocks. Different traverses were also made across the area, by Mr. James Richardson, between the Ottawa river and Smiths Falls on the Rideau, extending as far as the town of Perth.

GEOLOGY.

Geological
formations.

The geological formations found in the area comprised in this map-sheet may be briefly stated thus:—

Post-Tertiary.

Utica shales.

Trenton.

Black River.

Chazy shales and limestones.

Calcareous and Potsdam sandstone.

Mica, chlorite and hornblende schists and amphibolites, with some conglomerates.

Gneiss and crystalline limestones.

Granite, diorite, &c.

Granite-gneiss.

In the discussion of the several rock-formations, the Post-Tertiary deposits will be described in a later chapter.

PALÆZOIC FORMATIONS.

Utica Shale.

Utica shale.

While the several members of the Palæozoic time are represented at a number of points throughout the Ottawa valley and the country adjacent to the south, these appear to show higher and higher elevations proceeding westward from the vicinity of Ottawa city. In this way the lowest beds deposited directly upon the crystalline rocks vary from the Potsdam sandstone, largely developed near Ottawa to the Upper Silurian at the northern end of Lake Temiskaming.

Thickness
near Ottawa.

The Utica shale formation has a large development along portions of the lower Ottawa, where in the area to the south and east, there is probably a thickness of 300 to 400 feet. West of this, it has however not been recognized except at one locality on the slope of the

mountain ridge south of Clear lake in the township of Sebastopol, Renfrew county.

In 1896, these shales were found in a shallow ditch along the road up the mountain side, resting upon Trenton limestone which is exposed along the shore on the south-west side of the lake. The elevation above the water is about 90 feet, and the exposure is not well observed anywhere in the immediate vicinity except in the excavation. The elevation above sea-level is about 830 feet. As compared with the shales of the lower Ottawa basin, the difference in level of the two localities where these shales are found is, therefore, a little more than 600 feet.

Outcrop near
Clear lake.

The underlying rocks about Clear lake are gneisses and granites with occasional thin bands of crystalline limestone which form a prominent ridge rising to an elevation of about 600 feet above the lake at the base.

Geology of
Clear lake
and vicinity.

On the slope of the mountain along a road which ascends the hills about two miles west of this lake, debris of the shales was also observed resting upon the Trenton limestone, so that it is probable that a shallow outcrop of the shales extends at irregular intervals in this direction for several miles, though the rocks themselves are for the most part concealed by drift deposits. The shales at this place are of interest as showing that the rocks of the Palæozoic basin of the Ottawa at one time had a very wide development, and that they have been largely removed by the enormous denudation which has affected the whole area.

From the locality south of Clear lake, Mr. Wilson in 1896 made a collection of fossils which have been determined by Dr. H. M. Ami. Subsequent collections were made by Mr. L. M. Lambe of this department in 1897. Among these the following characteristic forms have been recognised.

Fossils from
Clear lake.

Climacograptus, sp. indt. too imperfect for identification.

Crinoidal fragments.

Leptobolus in. ignis, Hall.

Leptobolus sp.

Lingula Progne, Billings.

Lingula curta, Hall.

Plectambonites sericea, Sowerby.

Dalmanella testudinaria, Dalman.

Zygospira modesta, Say.

Trocholites ammonicus, Emmons.

Endoceras proteiforme, Hall.

Serpulites dissolutus, Billings.

Triarthrus Becki, Green, adult and larval forms.

Asaphus Canadensis, Chapman, (*A. latimarginatus*, Hall.)

Primitia Ulrichi, Jones.

TRENTON AND BLACK RIVER.

Trenton
limestone.

The rocks of these formations are limestones. The areas of the former are limited and have been recognized at but two places in the map-sheet. Of these the most westerly is on the shores of Clear lake already referred to, where broad ledges of the limestone underlie the Utica shales on the south-west corner of the lake and extend for some distance westward. They are exposed for about one mile and a half along the shore or to the point where the road turns south up the mountain to the Opeongo road. This area is referred to in the report of Mr. Murray for the year 1853. The limestones can be traced southward from the lake road near the west end for a couple of hundred yards where they appear to rest upon the crystalline rocks. They contain the characteristic fossils of the formation, and are in a horizontal position, without evidence of faulting.

Trenton
of Nepean
and Huntley

The second area of Trenton is in the eastern part of the map-sheet in the townships of Nepean and Huntley. They here form a narrow belt extending from the vicinity of the Canadian Pacific railway at Stittsville to the vicinity of Antrim which is two miles south of Kinburn station on the Canada Atlantic railway. The rocks of the formation pass downward directly into the limestones of Black River age, and only the lower portion of the formation is apparently here represented, since the transitional form *receptaculites* is recognized at several points. In the eastern part of Huntley township the formation is somewhat thicker. The breadth of these rocks, as seen on the road south of Marathon on the line between Huntley and Fitzroy, is nearly three miles, though there is some difficulty in fixing the exact limits of the formation. South from Huntley post-office the breadth of the formation is a little greater, but over much of this township there are extensive deposits of clay, so that the area of the Trenton limestones is somewhat conjectural, being determined partly by scattered outcrops. The strata lie everywhere in nearly horizontal layers and where exposures occur their age is recognized by characteristic fossils.

Character
of the
formation.

Area east of
Pakenham.

Another, but smaller area of these limestones is found on the crest of the ridge north of the Canadian Pacific railway between Pakenham

and Snedden's crossing. They rest upon the Black River limestones and the exposures are visible on either side of the line between the townships of Ramsay and Pakenham, with an approximate length from east to west of about one mile and a half, by half to three fourths of a mile in breadth.

The Black River limestones have a much greater development. They occur at a number of places, sometimes as isolated outcrops of comparatively small extent, but in other places in the eastern part of the area these rocks can be traced continuously for over twenty miles.

Black River
limestone.

Among the smaller areas may be mentioned the vicinity of Clear lake in Sebastopol township, where in the flat country to the west several good exposures can be seen. Among these is a point near to and on the road a short distance west of Clear lake post-office where these limestones form a low escarpment, resting against the crystalline rocks which show on the north. Further west on a road going south from a point about three miles west of the lake, good exposures of the massive limestones are seen near the base of the Brudenell ridge. The country from the lake westward in this direction is generally low and the formation apparently occupies a considerable area, the wester limit of which cannot be ascertained owing to the presence of drift sand. That it at one time extended over a much greater area than now exists, is shown by the finding of outcrops of similar rocks several miles further west on the road leading from Killaloo village to Brudenell post-office. The several occurrences of the Black River, Trenton and Utica in this area are all apparently of no great thickness, since they do not include in all more than a couple of hundred feet in vertical section.

Clear lake
outlier.

On the Opeongo road which extends westward from the village of Dacre across the Brudenell hills, another isolated outcrop of these rocks is seen resting upon gneiss and crystalline limestone with an exposed area of about one mile in length by a fourth of a mile in breadth. The beds are well seen in a knoll about three miles east of the end of Clear lake near the point where the road is crossed by Constance creek. They occur for the most part north of the road, but there is a small outcrop on the Opeongo road also. No higher rocks were observed at this place.

Opeongo
road.

Further east, on the north side of Calabogie lake in the township of Bagot, along the road leading past the north side of the lake to the High Falls of the Madawaska river, there is another small area of the Black River limestone which also appears on the south side of the

Calabogie
lake.

lake near Barryvale station and extends for a mile or more to the south of that place.

Ashdod
outlier.

On the roads west of Ashdod station on the Kingston and Pembroke railway there is also another small outlier which occupies the crest of the ridge. At all these places the formation is easily recognized by the lithological character of the rock as well as by the contained fossils.

Areas
near the
Ottawa river.

The distribution of the Palaeozoic formations along the Ottawa river has already been stated in a preceding report, since the greater number of these outliers is found in the map-sheet adjacent on the north. Along the Ottawa itself in the eastern part of the present map-sheet there is a large area of the same rocks extending to the south and forming a broad and well-defined basin. This is separated from the Ottawa below Arnprior by a prominent ridge of the crystalline rocks, consisting of granite, gneiss and limestone, which extends eastward to within about ten miles of Ottawa city, and divides the Palaeozoic basin of the river from that which occupies portions of the townships of McNab, Fitzroy, Ramsay and Huntley, and thence extends south to the St. Lawrence.

In this large basin all the Palaeozoic formations are represented from the Medina to the base of the Potsdam sandstone.

The outliers of the Trenton in this area have already been referred to. As to the remaining formations of the series these are frequently intimately associated through the agency of faults which traverse the area in several directions.

Black River,
west of
Arnprior.

South of Sand Point, five miles west of the town of Arnprior, the Chazy shales seen along the Ottawa are capped by the limestones of that formation, but the upper part of the ridge, rising to an elevation of about one hundred feet above the river, is composed of Black River limestone which is well seen on the south side of this ridge in broad ledges in places filled with the fossil *Teradium fibratum*. From a quarry on the south slope other characteristic fossils have also been obtained. South of this ridge the country is flat for some miles and clay-covered, but masses of red granite appear at intervals, so that the Palaeozoic formations do not probably extend in this direction much beyond the limit of the ridge itself.

South of
Arnprior.

South of Arnprior on the road to White lake which is about eight miles distant, the country for nearly five miles is largely clay-covered, but in the valley of the Madawaska the crystalline rocks show in the bed of the stream for a short distance above the town. The underlying

rocks are, for the most part concealed, but masses of corals are found sometimes in the bed of the stream which indicate the probable presence of Black River limestones at no great distance. About five miles south of the town a somewhat prominent escarpment of these limestones comes to view and holds the characteristic fossils of the formation at many points. These limestones apparently rest upon the crystalline rocks of the Hastings series, from which they are probably separated by a fault extending west from Pakenham along the face of the ridge of crystalline rocks. The northern margin of this Black River area is also terminated by another fault which divides the limestones from the Calciferous formation. The western boundary is concealed by heavy deposits of marine clays and the relations to the underlying crystallines are not seen. North of this area and west of Arnprior for several miles are a number of scattered outliers of the Calciferous dolomite which rest upon the crystalline limestone and sometimes on granite, but these do not appear on the western margin of the Black River basin, so that it is possible the formation may also be terminated by faults on all sides. At Pakenham village the Black River limestones are well seen in the bed of the Mississippi river where they hold an abundance of corals such as *Columnaria Halli* with *Actinoceras Bigsbyi* and other forms characteristic of the formation.

Escarpment.

Limits of the Black River area.

Fault.

These rocks are separated by a well marked fault from the Calciferous dolomite at this place, the latter showing in broad ledges along the south side of the river and passing down into the Potsdam sandstone a short distance to the east.

In the townships of Fitzroy and Huntley several of the formations are exposed, ranging from the base of the Potsdam sandstone to the Trenton. The Black River limestone is conspicuous at a number of places and is affected by faults, some of which are important.

The northern limit of the basin of these rocks is apparently defined by the great fracture which extends north west from near Fallowfield in Nepean township on the east, and which follows the southern flank of the ridge of crystalline rocks in the direction of Arnprior.

Northern limit of Black River limestone.

On or near this line of fault the Black River limestones are seen along the road which follows the town line between Huntley and March townships on lots 8 and 9, range I, of the latter, in contact with the ridge of crystalline rocks.

Faulted contacts.

Further west, just south from Carp river crossing, on the road south from Carp village a small outcrop is also seen, showing the con-

tinuance of the rocks of the same formation in this direction in close proximity to the underlying crystallines.

Fitzroy
township.

Passing into the township of Fitzroy, similar Black River limestones are well exposed in an escarpment in which a quarry is located on lots 2 and 3, range IX, also near the ridge. The dip of the limestone at this place is N.W. $< 10^\circ$, but it becomes reversed, a short distance to the west, to S.E. $< 4^\circ$.

Limit of
formation
near Kinburn.

The western limit of this Black River basin is a short distance west of the road leading from Kinburn to Pakenham. The limestones are seen in the bed of a small brook a short distance north of the village of Antrim and are well exposed along the road south-east from that place between ranges III and IV; but the southern edge of the escarpment of these rocks is found a short distance south of this road, since the underlying Chazy is well exposed in a quarry on range III, lot 4, about 300 paces south of the road east from Antrim. The Chazy rocks do not apparently reach the road south from Marathon to Panmure which is along the town line of Huntley and Fitzroy, as the Black River rocks are exposed all along this road coming out from beneath the Trenton capping, about one mile or so north of Panmure corner.

Area in
Huntley
township.

From this place they are exposed in an apparently unbroken belt both to the east and west, in the latter direction reaching the village of Pakenham and eastward extending across Huntley into Goulbourn township where, on the town line, they have a breadth of rather more than two miles, capped by Trenton on the north of the Stittsville area and underlaid by the Chazy limestones on the south. The breadth of this Black River basin, with its overlying Trenton capping in the township of Huntley, is about six miles.

Pakenham
to Almonte.

A third area of the Black River limestones is seen along the north side of the Mississippi river, extending eastward from Pakenham to the north of Almonte. It is affected by faults all along its northern margin which separate the limestones of the formation from the Potsdam sandstone on lots 14 to 20, ranges XI and XII, and in connection with this is a small outcrop of the crystalline rocks, consisting of granite, gray gneiss and limestone which appears on the line between these two ranges on lots 19 and 20. The southern margin is separated from the Calciferous by a fault at Pakenham village, but further east it is marked by the underlying Chazy limestones on the roads north of Snedden station on the Canadian Pacific railway and to the north of Almonte. The eastern limit of this area is apparently about lots 8 and 9, range XI, Huntley. Several faults are seen along the north side of the Mississippi river to the south-east of Pakenham village. Through-

FIG. 1.

out the extent of these outliers and basins the characteristic fossils of the formation are readily recognized.

CHAZY.

Where possible the Chazy shales which represent the base of this formation have been separated from the limestones of the upper portion.

Chazy shales and limestones.

These have not been recognized at any of the isolated outliers in the western portion of the area comprised in map-sheet, No. 119, but they have a somewhat widespread development in connection with the great Palæozoic basin of the Ottawa district.

Near the Ottawa river, in the township of Torbolton the lower shales appear on the south shore of the river nearly two miles east of Berry's wharf where they rest upon the Calciferous dolomites, the lowest beds consisting of a rather coarse gritty sandstone. The strata have a low dip of two to three degrees to the north, and are capped inland a short distance to the south by the limestones of the formation which form the crest of the ridge south of the wharf and extend southward to the depression occupied by Constance lake and creek. They here form the highest member of the Palæozoic series lying to the north-east of the ridge of crystalline rocks which extends from Arnprior to the township of March.

Ottawa river near Berry's wharf.

Contacts.

Further west the same succession of shales, capped by limestones, occurs to the east of Sand Point above the town of Arnprior, the relations of which will be pointed out in the report on the Ottawa river as represented on map-sheet No. 122.

Area near Sand Point.

The principal areas of these rocks are found in the townships of Fitzroy, Ramsay, Huntley and Beckwith. In the first named township they apparently underlie the Black River basin on the west, and are in contact with the rocks of the northern ridge by a fault already described. They form a tongue extending south-east from the road leading to Pakenham from Antrim, where they separate the two areas of the Black River basin, on the west.

Areas south of Ottawa river.

East of Pakenham they are exposed at several points along the north side of the Mississippi river, and at Almonte the shales at the base are seen in cuttings on the line of the Canadian Pacific railway, as well as on the north bank of the river; but in the northern part of the town these are overlaid by the Chazy limestone which is exposed as far north as the south line of Huntley township, where it passes beneath the Black River formation.

Shales at
Appleton.

Goulbourn.

At Appleton also the shales are well seen on the north side of the Mississippi river along the roads, and thence east they continue into the township of Beckwith; where, although the surface is largely occupied by drift, they may be traced by occasional outcrops to the north of Blacks corners as far south as the line between ranges V and VI, including in this part of the basin the valley of the Jock river. The shales are also well exposed at Ashton village in the bed of this stream and they form a well-defined band in Goulbourn township extending east from this place to the road from Richmond to Perth, the contact with the overlying limestones being seen on the road south-west of Munster village at the crossing of the Jock and on the road near Dyers Hill, a short distance to the north-east of the crossing of the same stream.

Their contact with the underlying Calciferous is also well seen near Dyers Hill post-office and on the Jock river a short distance east of Ashton village. The outline of the formation is somewhat irregular, following, to some extent, the surface contours.

Faults.

Huntley
township.

In connection with the fault, which extends south-east from Pakenham across the southern part of the township of Huntley, the Chazy limestone is seen on the road south-west of Panmure, and is underlaid by the shales which are exposed in the bed of a brook on the line between ranges X and XI, lots 22 and 23. They here overlie the Calciferous dolomites which are cut off against the Black River formation by the fault in connection with the outcrop of the crystalline rocks of Huntley, already referred to. It is probable that another fault comes in on the north, which crosses in a south-west direction a short distance to the south of West Huntley church, on lot 15, range IX, since the Calciferous at this place is in close proximity to the Black River limestones, which form a somewhat prominent escarpment in this direction, extending westward to Panmure corner. This area in southern Huntley appears to be much affected by faulting, and the several formations are broken off abruptly at a number of points.

East of West Huntley post-office this faulted area appears to die out and the relations of the Chazy and Black River formations are more regular. The limestones of the former, here comprise a somewhat extensive area, occupying the greater portion of the township of Ramsay north of the Mississippi river, the south-eastern part of Huntley, and the south-western portion of Goulbourn, with a breadth of about six miles on the line between Huntley and Goulbourn, and thence south; while the area extends eastward across the latter township to the vicinity of Richmond.

CALCIFEROUS AND POTSDAM.

The Calciferous dolomite and Potsdam sandstone may here be described together since the former passes down into the latter through transition beds, the thickness of which ranges from 20 to 30 feet. Calciferous and Potsdam.

The areas of these formations are entirely confined to the eastern Arnprior portion of the map-sheet. The dolomites of Calciferous age are exposed at Arnprior, resting in patches on the crystalline limestones of that place. They are in contact with these by a fault in the western part of the town and a deposit of hematite occurs which was mined some years ago along the line of junction. Their extension west in the vicinity of the Bonnechère will be described in the report on that area, comprised in map sheet, No. 122.

East of Arnprior in the district between the Canadian Pacific and Canada Atlantic railways the dolomites apparently occupy a triangular-shaped area extending eastward as far as the Mississippi river and underlying the Chazy and Black River of the Huntley basin. The exposures are few, and to the south-west the Calciferous is apparently bounded by a fault which divides it from the Black River, while to the north it rests upon the crystalline rocks, though probably a fault extends along the southern flank of this ridge, since there is a small outcrop of Potsdam sandstone on the crest of this ridge near the line between ranges X and XI. Fitzroy, on the road northeast from Kinburn, on lots 10 and 11. This place is at an elevation of 200 feet or more above the valley of the Carp at Kinburn, where Black River limestone occurs. Faults.
Potsdam north of Kinburn.

In Torbolton and March townships the dolomites are exposed at a number of places. They form a continuous belt, extending south-east from Fitzroy village at the mouth of the Carp river, on the Ottawa, to the shores of the Ottawa river west of Britannia. They are well seen on the roads which cross the flat country in which Lake Constance is situated, and rest upon Potsdam sandstone to the south of March corners and thence west to Kilmaurs post office. The Potsdam sandstone terminates in this direction at the line between Fitzroy and Torbolton townships at about lot 12 of the former. The sandstones continue thence eastward along the northern flank of the ridge of crystalline rocks in a narrow belt, passing up into the dolomite in the township of March. Torbolton and March.

South of this ridge, the sandstone and dolomite are brought to view by the fault in the southern part of the township of Huntley. They Faults.

are exposed at intervals on ranges IX, X, XI and XII, extending from lot 12 to 22, their southern margin being terminated by a fault for the whole distance which separates these rocks from the Black River limestones.

Pakenham.

The southern margin of these formations rests upon the great area of crystalline rocks which occupy the principal portion of the area comprised in the map sheet. From Pakenham east, the lowest member of the Palæozoic formation is the Potsdam sandstone which is seen at frequent intervals as far as the shores of Mississippi lake. The sandstone belt is irregular in outline following the sinuosities of the underlying crystallines which evidently formed an old shore line at the commencement of Palæozoic time.

Mississippi lake.

From the upper end of Mississippi lake, through the western part of the township of Drummond, the sandstone is concealed and the dolomite rests upon the edges of the crystalline rocks; but approaching the town of Perth the sandstone, with an occasional mass of arkose or coarse conglomerate, again appears. To the south-west of Perth the sandstone extends through the southern part of the township of Bathurst almost to the shores of Christie lake, forming a belt from one to two miles in breadth. A southern arm of this Potsdam basin extends south from the Scotch Line post-office into North Burgess reaching as far in this direction as Black lake.

Rideau lake.

East of Perth the sandstone occupies the southern part of the township of North Elmsley and is well exposed around the lower end of Rideau lake, extending as far east along the Rideau river as Smith Falls. It passes upward into the Calciferous dolomite on all sides, the latter being the prevailing rock over the townships of Beckwith, Drummond, South Elmsley, Montague and thence out to the St. Lawrence at Prescott and Brockville.

Transition beds, fossils.

Over certain parts of this Calciferous area the denudation of these rocks has been such as to expose the underlying sandstones or transition beds at a number of points. It is from these transition strata, in which the sandstone becomes in places quite calcareous, that the best fossils are to be obtained, since through the process of weathering, the organisms, which are silicified, stand out from the layers and can be readily removed.

Conglomerates.

The lowest beds of the Potsdam in places are a somewhat coarse conglomerate or arkose, the pebbles of the crystalline rocks sometimes being large masses up to two feet in length. These are cemented by a coarse sandy and sometimes calcareous paste. While the sandstones

as a rule are grayish or sometimes yellowish-gray ; in places they are often coloured red through the presence of hematite. This sometimes assumes the form of ore deposits of this mineral, capable of being mined. These deposits are usually in the form of irregular pockets and vary in quality from impregnated sandstones, in which the siliceous matter predominates to an iron ore of considerable purity.

The character of the sandstones and overlying formations in this district has been given in the earlier reports of the Geological Survey, much information being contained in the *Geology of Canada*, 1863, and in the several reports by Mr. H. G. Vennor from 1869 to 1874, as also in that by Mr. A. Murray, for 1853.

THE CRYSTALLINE ROCKS.

The work of the Survey on the crystalline rocks of this district dates back for nearly fifty years. The first exploration in the region was undertaken by Mr. A. Murray in 1852-53 or only nine years after the commencement of the work of the Geological Survey in Canada, in the area a short distance west of that contained in the present map-sheet. In that year a traverse was made of the district north from Kingston, by the chains of lakes which intersect the country in all directions, to Sharbot lake, and thence it was continued through the townships of Olden, Oso and Kennebec, the return journey being made by way of several rivers and lakes to the St. Lawrence at Belleville. The results of this field-work are given in the report for 1852-53. In this report the term Laurentian which had shortly before been devised by Sir W. E. Logan, to cover a large portion of the crystalline series in Canada, was employed.

The second exploration in the western part of the area was in 1865 and was carried out by Mr. Macfarlane. This was undertaken primarily with the object of ascertaining the value of certain deposits of hematite which had recently been reported as occurring in this portion of Ontario. Mr. Macfarlane's exploration led to important results, not only in the finding of iron deposits, but also as giving an expression of opinion as to the geological horizon of some portions of the crystalline rocks which had hitherto been classed under the head of Laurentian. Thus, in regard to the occurrence of certain of the granite masses which had previously been regarded as altered or metamorphosed sediments, it is stated that 'It is not in all cases possible, without a careful study of their attitude, to say whether these granite-like masses are intrusive rocks ; as remarked on page 587 of the *Geology of*

Canada, 1863', "the coarse grained granitoid and porphyritic varieties (of the Laurentian (gneiss) which often form mountain masses, sometimes have, at first sight, but little of the aspect of stratified rocks, and might be taken for intrusive granites." This remark arose doubtless from the expression of the theory as put forth in the *Geology of Canada, 1863*, that the Laurentian represented the first great development of sedimentary rocks in a highly altered condition.

Sir W. E.
Logan's
views.

In describing certain of the rock-formations there met with, especially as regards intercalated schistose conglomerates, which have since been recognized as an integral portion of the Hastings series at various points, Mr. Macfarlane also calls attention to the fact that they are not unlike some of the Huronian rocks; and in connection with this Sir W. E. Logan remarks that 'the rocks of Marmora and Madoc and other townships in Hastings, have been provisionally classed with the Laurentian series, with which they appear to be conformable, and in common with which they hold *Eozoon Canadense*, in which however the canals and interspaces of the fossil are filled with carbonate of lime, instead of any of the silicates filling them in other parts. These Hastings rocks may be a higher portion of the Lower Laurentian series than we have met with elsewhere. It is not to be inferred from the presence in them of a schistose conglomerate that therefore they are Huronian. Some may be disposed to compare the Hastings rocks with the metamorphic Lower Silurian of Eastern Canada, but the micaceous limestones of Hastings more closely resemble the micaceous limestones which run from Eastern Canada into Vermont, on the east side of the Green Mountains, and which, from their fossils, are known to be Devonian.'

The work of Mr. Macfarlane was taken up in the following year by Mr. H. G. Vennor, who in, 1866, began a detailed study of the rock-formations in this district and continued the work of mapping their distribution for some years. The first portion of this work was confined also to the area south of the district comprised in this map-sheet, and included the structure of the several groups of strata which had now become regularly known as the Hastings series, from the fact of their first being studied in the county of Hastings. This work was largely commenced from the economic standpoint, in order to ascertain the horizons at which certain deposits of the metals, in which the gold of Madoc and Marmora, which had recently come to light, formed an important element. In so far therefore as the first few years of Vennor's work is concerned, it may be regarded as beyond the scope of

* Rep. Geol. Survey. 1866, page 93.

this report, but as this exploration gradually progressed eastward it reached the county of Renfrew, and finally the Ottawa river, so that for several years Vennor's labours were confined to the area now under discussion. As in the course of this series of examinations the rock formations first encountered were found to be traceable across the entire distance from Hastings county to the Ottawa, the relations found in the one portion of the field may be considered as to a large extent applicable to the whole. Subsequently this series of explorations was continued across the Ottawa and extended northward for about ninety miles along the Gatineau river, and the other streams to the east of this, it it reached the great anorthosite masses to the north of the city of Montreal.

As the result of the study of these rocks by Vennor for several years, they were arranged under three heads, in the Report for 1866-69 styled respectively Divisions A, B and C. In the first was placed a great mass of reddish syenitic and granitic gneiss, portions of which were without apparent stratification, and were held to form the base of the series. Above this was a series of grayish and flesh-coloured gneiss, passing into a mica schist, with some diorite, above which was included several hundred feet of crystalline limestone, sometimes magnesian, and in which, at several places, the remains of Eozoon were found.

Work by
Mr. H. G.
Vennor.

The second division consisted of hornblende and pyroxenic rocks with schists of various kinds, also including diorites and beds of magnetite; while the rocks of Div. C, comprised crystalline magnesian limestones, mica slates, quartzites, &c., with some conglomerates. The lithological differences of certain portions of these divisions from the rocks which were hitherto regarded as Lower Laurentian, were at the same time pointed out.

In the report for 1870-71 these divisions were condensed and the statement was made as regards their probable horizons that those of division A might be classed as Laurentian, while divisions B and C were regarded as probably Huronian.

Two
divisions.

The results of Vennor's explorations appeared in several annual reports, extending down to 1876-77. In this last his work north of the Ottawa is also described and the connection was made between the rocks of the Hastings and the Grenville series, the one being regarded as the equivalent of the other. From the fact that the views as to the structure of the Laurentian still maintained the presence of an upper series of Anorthosites, at that time considered as

Vennor's
conclusions,
1876-77.

an unconformably overlying series of altered sedimentary rocks, which were supposed to cap the Grenville and Hastings series at several points, or to constitute a portion of the Hastings series to the south of the Ottawa river, it became necessary, in order to support the theory already advanced, to place all these rocks, beneath the Anorthosites, or in the Lower Laurentian; and, in the last of the reports alluded to, Vennor divides the crystalline rocks of the Ottawa district into two grand divisions, viz., 1st. a great gneissic and syenite series without limestones, and 2nd., a thinner gneissic series with labradorites and limestones, which were capped by the Lower Silurian sediments comprising the Potsdam sandstone and other formations to the top of the Trenton.

Eozoon
Canadense.

One of the most important factors leading to the change of opinion on the part of Vennor in placing the rocks, which he was at first inclined to regard as Huronian, in the Lower Laurentian, was the finding of Eozoon in certain of the limestones which he had assigned to division C; and in fact, so long as the contention was maintained that the presence of this fossil was indicative of a Laurentian horizon, no other scheme of classification was admissable.

Dr. Selwyn's
Views,
1877-78.

Although the igneous nature of the Anorthosites was maintained by several of the leading geologists both in America and Europe for many years prior to this work in Canada, it was not till after this final report of Vennor's had been published, that this view was adopted by the head of the Canadian Survey. Thus in 1877-78, Dr. Selwyn, from a study of the work of Vennor, as contained in his field notes on the area north of Montreal for that year, expressed the view that, if these observations were correctly made, the Anorthosites should be removed from the position they had so long held as the upper altered sedimentary portion of the Laurentian, and should be regarded, not as altered sediments, but as igneous rocks of later date than the Grenville and Hastings series with which they were associated. So much was Dr. Selwyn impressed with this new view of the structure, after examination of the facts then available, that he reconstructed the scheme of formations for the lower crystalline rocks, by assigning to the Laurentian proper only the lowest series of gneiss, granite and syenite which showed no trace of sedimentation, while the sedimentary gneiss, limestone, quartzite and schists, which constituted the greater portion of the Grenville and Hastings series, was assigned to the Huronian, and made the equivalents of the crystalline rocks of the eastern townships of Quebec, a series which had been long known as the "altered Quebec group."

The view that the Anorthosites were originally of sedimentary origin doubtless arose largely from the fact that a gneissic or foliated structure was visible in these rocks at many points ; but though this change of view was advocated by the then Director in 1878, so important were the issues involved considered to be, that the facts obtained were not at that time regarded by him as sufficient to warrant altogether an official change of opinion, in view apparently of the supposed Laurentian horizon of Eozoon : and in the scheme of nomenclature, put forward in 1881-82, a return was made to the original scheme of classification, the Laurentian being again divided into a lower, middle and upper portion, succeeded upward by the Huronian. Later the work of Dr. Adams on the Anorthosite areas north of Montreal conclusively showed that these might be regarded as unmistakably intrusive masses of later date than the rocks of the Grenville series with which they were associated. These rocks were thereupon definitely removed from their position as the upper member of the Laurentian system and the rocks of this series were then arranged under two heads, viz., a lower series comprising the lower division of Vennor, and an upper series of gneiss and limestone with quartzites, &c., which were embodied in the Grenville and Hastings series.

Modification of Selwyn's views, 1881-82.

Work by Dr. Adams.

The similarity of these two series (the Hastings and Grenville) and their equivalence in point of time was pointed out by Vennor as far back as 1876. In the report for that year he also regards the Anorthosites as constituting the upper member of the Laurentian, but expresses doubt as to whether this is the correct view of the structure. Assuming it to be so however for the present, he concluded that all the underlying rocks, including the lower gneiss and upper series of gneiss and limestones must be regarded as Lower Laurentian, the term middle Laurentian thus being eliminated from the nomenclature of the subject.

Grenville and Hastings series practically the same.

In the mean time the original contention, that the rocks of the Hastings series might be Huronian was still maintained by some observers. The great resemblance of many of the rocks which made up the series to certain rocks found in New Brunswick and in eastern Quebec, which had been regarded and described in the reports of the former province as Huronian, was very marked, and their study under the microscope showed that, as compared with the rocks of the lower granite gneiss, the two were largely different in origin ; since, while all the evidence as regards the latter went to prove that large portions were really altered igneous rocks, without any trace of sedimentary structure, in the case of the upper series the evidences of sedimentation were very often apparent. In both series, however, large masses of

Probably Huronian.

rocks, similar in character to those of the lower series, are associated ; and in many cases, where their relations could be clearly made out, it was recognized that the limestones and associated gneiss, with certain of the schistose portions and conglomerates, were unconformable upon the lower gneiss, and that the latter had invaded the former, after their deposition when presumably in a plastic condition.

Dr. Sterry
Hunt's views,
1878.

In 1878 Dr. Sterry Hunt, in his report to the Second Geological Survey of Pennsylvania, reviewed very exhaustively the whole subject of the crystalline rocks of the United States and Canada ; and in discussing the question of the rocks of the Hastings series places them in the Huronian system, but does not recognize their equivalence with the Grenville series, which he still regarded as a member of the Laurentian. This view of Hunt's is apparently due to the fact that he still regarded the Anorthosites as altered sediments which, however, he separates from the Laurentian proper and describes under the head of Norian, but as beneath the Huronian proper. The Hastings series in this case was placed in the same general group as the rocks of the altered Quebec series, the Montalban or mica schist series of the White Mountains, and the lower Taconic of Emmons as occurring in the state of Vermont.

Logan's
Grenville
limestones

The peculiar arrangement of the crystalline limestones of the Grenville series, as originally laid down by Logan in his manuscript map of the Grenville district, north of the Ottawa river, in which area four and possibly five, distinct horizons of these calcareous rocks were supposed to exist, separated by thousands of feet of reddish orthoclase gneiss, led to what is now regarded as an incorrect interpretation on the part of Vennor of the structure of the similar rocks west of that river. Thus, in the study of the rocks of the Hastings group, Vennor, recognizing that the two series were one and the same in great part, since the limestones and associated strata of the former were readily to be traced into the similar divisions north of the Ottawa from the county of Hastings, endeavoured to parallel the several bands found in the western area with those which had been located in the Grenville district ; but in this attempt much difficulty was experienced. The tracing of these limestone bands for long distances was not, in all cases found to be practicable, for, while certain of them could be followed for some miles, in other cases their continuity was affected by what appeared to be large intrusive masses of granite, or sometimes diorite, which sometimes abruptly terminated the bands or, in the case of the granites, deflected them from their regular course.

In 1891 the writer began the detailed examination of the area north of the Ottawa, in the typical district where the rocks of the Grenville series were first studied; and, in the course of the next three years, carried these explorations along the Ottawa river as far west as the Rapides des Joachim, about fifty miles west of the town of Pembroke, an area comprised in map-sheets Nos. 121 and 122. Passing thence to the study of the district south of that river, the examination of these rocks was continued southward and westward along the Bonnechere, the Madawaska and the Mississippi rivers, and over the intermediate country, comprised in the sheet more immediately under discussion known as No. 119. At the same time the area embraced in the map-sheet adjoining on the west, which comprises a portion of the district first studied by Vennor, was undertaken by Messrs. Adams and Barlow. The study of the rocks in these adjacent areas has since been consecutively carried out, so that the unravelling of the structure of this complicated group of formations, pertaining to the crystalline rocks in this part of the province, has now reached a fairly satisfactory conclusion. It may be stated that the views reached by the several workers in these fields are in perfect harmony, as regards all the important points of structure observed, the conditions found in the two areas being practically the same. Certain minor matters of detail yet remain to be completed, but it is hoped that the true relations of the Hastings and Grenville series to each other have been ascertained, as also their relations to the great underlying granite-gneiss series, which has for some years been held to represent the fundamental rocks of the district, and regarded as constituting what may be styled the Laurentian proper. Some of these results have already been given to the scientific world in several papers presented to the Geological Society of America and elsewhere.

Work of
Drs. Adams
and Barlow.

The
Laurentian
proper.

In discussing the geological structure of the area comprised in these map-sheets it must be premised that a close and detailed study of every portion is not possible. Large portions of the district are as yet not opened up by roads, and even woodpaths, which at one time existed, have now become practically impassible owing to the forest growth. Often the underlying rocks are concealed by large deposits of sand and loam, so that the extension of certain bands which are observed at widely separated intervals must be largely conjectural.

Present
arrangement
of crystalline
rock.

The rocks in the area now being considered may be roughly divided into several groups as follows.

1st. Granite-gneiss and syenite which apparently represent the oldest series upon which the others rest.

2nd. Gneiss, often grayish or reddish-gray, sometimes highly quartzose and garnetiferous, but of various shades of colour, certain portions of which pass upward into limestones.

3rd. Amphibolites with schists, sometimes micaceous, sparkling and glistening, often containing garnets, at other times chloritic, hornblende or dolomitic, with altered slates and true conglomerates and limestones.

4th. Granites and diorites, some of which are clearly intrusive and newer than the rocks which they penetrate.

THE UNDERLYING GRANITE-GNEISS SERIES.

The granite-gneiss.

In all the reports on this area the rocks of this division have been recognized. They have been regarded, in the main, as representing the oldest or fundamental gneiss, and as constituting what has been frequently styled the lowest Laurentian.

Mr. A. Murray, 1853.

In the report of Murray, 1853, on the country along the Petawawa river and to the south and west, the existence of this lowest granite gneiss was pointed out. Over great portions of this area there appears to be an almost entire absence of the limestone and gneiss of the upper division, which are the predominant rocks of the Grenville and Hastings series. Along the north side of the Ottawa river, these newer rocks come in opposite the lower end of Allumette island, the limestones first showing about two miles west of the mouth of Black River and extending for some miles along the course of that stream northward. Along the north side of Allumette Island from the village of Chapeau, and on the roads along both sides of the Ottawa, in the vicinity, the reddish granite-gneiss is the prevailing rock.

The Bonnechère, Madawaska districts.

This old granite-gneiss is also well exposed along the upper part of the Bonnechère above Go'den Lake, further to the south; and continuing in its course it occupies a large area in the west and north-west portion of the map-sheet under discussion. In this direction it is well exposed in the townships of Lyndoch, Abinger, Denbigh, Griffith and in portions of Metawatchan and Brougham, in all of which the rock is largely grayish or reddish-gray granite-gneiss.

Relations of the crystalline limestones.

In certain portions the foliation is well defined, but in other places it becomes indistinct; and the rock, as a whole, presents very different physical features from those that are found in the banded gneiss of the Grenville and Hastings series. Throughout the areas just designated the limestones of the upper series are, for the most part, lacking, and

where they do occur their extent is very small as compared with the great masses which are found elsewhere. In places the limestone appears to rest upon the old granite-gneiss, but at others it is associated with a series of schists, amphibolites and gneisses, which are sometimes very garnetiferous, and which in turn rest upon the underlying granite-gneiss.

While the strike of the underlying, as well as of the newer rocks, follows a general north-east course, this direction is frequently and sometimes abruptly changed, so that the strike of much of the rocks of the newer series shows a tendency to follow the outlines of the underlying granite-gneiss. Instances of this are well seen in the township of Denbigh, as also at other points, where the lower series seem to have invaded the upper or overlying schists and limestone and diverted their strike for a considerable distance.

Irregularity of distribution

In the list of townships where the reddish granite-gneiss, which we now regard as constituting the lowest member of the crystalline series, is especially well represented, may be mentioned Grimsthorpe, Anglesea, Effingham and Ashby. In the second of these, which is almost entirely unopened to settlement, a large sheet of water, known as Loon lake, which intersects the central portion of the township, is reached by a road leading in from the Addington road. This latter road extends from the township of Kaladar to the Madawaska river, crossing the western portion of the township of Barrie, and furnishing, for the greater part of the distance, a very good cross section of the rocks of this area.

Granite-gneiss.

Around Loon lake the reddish granite-gneiss is well exposed for the greater part of its outline. It forms large ledges along the north and west shores, and thence apparently occupies the northern and western parts of the township entirely. In much of this rock but slight traces of foliation are visible. The south-east angle of the lake, to near the outlet of the Skutematta river, is apparently largely occupied by similar rocks, but at this point the rock changes to a black hornblende gneissic schist or amphibolite which occupies all the south-eastern portion of the lake and extends across the country to the road through Barrie and on for some miles to the east. These black and green rocks are cut by dyke-like masses of red syenite or granite, there being often a small quantity of quartz in its composition, and these have broken up the hornblende rock with which they are now associated. Some of these dark rocks show but slight traces of foliation. They hold irregular bunches of quartz, while in the portions that are schistose quartz strings occur along the layers.

Loon lake.
Black hornblende rocks.

The
Addington
road.

Kaladar
gold mine.

Snow road.

The granitic rocks also occupy the whole of the large point which separates the two arms of Loon lake and also the large island in the south-east bay. Thence they extend along the road from the lake to the Addington road and are exposed for some miles northward, continuing as far as Eagle hill in the township of Denbigh. On the road going south towards Kaladar, the black hornblende rocks which were noted on Loon lake are overlain about lot 22, Addington road range, Barrie, by green chloritic schists, and thence on to Cloyne post-office, which is on lot 15, the green rocks prevail. In places these are distinctly dioritic in character, without foliation, but in other places they assume a schistose structure and present the aspect of true schists of the Huronian series as seen elsewhere. These green, sometimes slaty, schists, with occasional brownish bands of dolomite, thence extend southward into Kaladar township almost to North Brook post-office. Before reaching this place a band of slaty conglomerate occurs, the rock having a green slaty paste with quartz pebbles. From this post-office south to the road leading west to the Kaladar gold mine, the surface is largely covered by sand drift, but occasional ledges of grayish granite appear. On the path from this west road to the gold mine schists and slates come in, with bands of schistose conglomerate containing pebbles of quartz, which are drawn out along the lines of schistosity. The gold mine at this place occurs in this series of slates and schists, in which are rusty black bands with irregular bunches and strings of quartz. In these the gold is sometimes visible to the naked eye. The strike of these rocks is N. 25° E. with an east south-east dip of 70° to 80°. The principal mineral, in these schists is iron pyrites, with which the gold is generally associated. Bands of dolomite, brown-weathering and rusty, sometimes occur with the slaty beds which in places become true mica schists. This series of rocks, with their contained conglomerate bands, is continuous for many miles to the east, appearing at intervals in Clarendon and Palmerston townships, where their associations will be again referred to.

The townships of Grimsthorpe, Effingham and Ashby are large extent unsettled, the surface being generally rough and probably almost entirely occupied by the granitic rocks which offer little inducement for the pursuit of agriculture. In the former roads exist in the area on this map. In Effingham, the Addington road which skirts the west shore of the great Mazinaw lake for some miles, crosses, for a short distance, into the eastern margin of the township, while in Ashby the only highway is the "Snow road" which leaves the Addington road at the foot of Eagle Hill, and crosses a very rough and hilly country to Weslemcoon lake, which lies on the

southern edge of the township. The road here crosses the creek connecting this lake with Otter lake, and thence, traversing the hills along the north side of Weslemcoon, crosses the Mississippi branch of the York river into the township of Mayo. This road is naturally very rough and but little travelled. There are only two settlers in the whole distance west from Ferguson Corner and the country all along is hilly with great masses of reddish-gray and grayish granite-gneiss which is usually moderately fine-grained. The rock is generally foliated but sometimes this feature becomes indistinct.

Weslemcoon, Otter and Thirty Island lakes are all important sheets of water in the southern portion of Ashby. The former is very irregular in outline, with long points and numerous islands. It extends into the northern portion of Effingham and at the south end a creek enters from Little Weslemcoon lake, the latter extending nearly to the centre of the last named township. From the south east end of the last lake a portage track extends across to the head of the Mazinaw lake, a distance of about four and a half miles.

The whole of the township of Effingham, as far as yet examined, appears to be occupied by the reddish and grayish Laurentian granite-gneiss; and a similar rock constitutes the entire shore of the four lakes just mentioned. This rock is composed principally of reddish or grayish feldspar, black mica and some quartz. The strike along the Snow road is about N. 60° E. with a dip to the north-west, but at the end of the long west bay on the angle of Effingham, this changes to S. 25° E. < 25° to 30°. At the creek between the two Weslemcoon lakes the rock has a grayer tint. The presence of dykes of coarse red pegmatite, sometimes of large size, is often noted. The same character of gneiss extends around the shores of Otter lake, and also occurs at Thirty Island lake. The surface soil of this township has, over many miles, been burned off and the bare ridges of the gneiss, often weathering a dirty white, are exposed in all directions, in places supporting a small green growth from which rise numerous dry trunks of the pine trees, which at one time apparently covered this area.

The township of Addington, like those just described, is also largely unopened for settlement. The Addington road traverses the western part near the line of Effingham, keeping near the shore of Mazinaw lake to its head, whence it follows along the valley of the Mississippi creek to Fergusons Corner at the foot of Eagle Hill in Denbigh. The north eastern portion is traversed by several roads, the chief one being the Snow road which, continuing from Eagle Hill, crosses the southern part of Denbigh into Abinger, whence it crosses Miller, Clarendon and

Palmerston townships to the line of the Kingston and Pembroke railway, near the point where it crosses the Mississippi river. This road affords a very good line of section across the south-west portion of the map-sheet.

Mazinaw
lake.

In the western part of Abinger also, and extending half-way across the adjacent township of Barrie, lies the Mazinaw lake, one of the most beautiful sheets of water in the province, and noted for its magnificent cliff which rises abruptly from the eastern shore to a height of 360 feet above the water at its base. Fine exposures of the reddish and gray lower gneiss are seen along the shores, the strike of the rock being generally N. 60° E. with a dip to the southeast of 45° to 60°. Along the face of the cliff, which is in the northern part of Barrie, there are bands which contain pyrites, and these by weathering have stained the face of the cliff with different shades of brown in irregular patches. These stains have by the Indians been regarded as representing old Indian paintings*. About one mile and a half from the foot of the lake a stream enters from the east which drains several lakes of good size, the principal of which are called the Kishkebus and the Shahbomekah or sometimes the Buck lakes. The reddish granite-gneiss continues southward along the shore of Lake Mazinaw from the upper end to the mouth of this creek, and extends eastward for some miles; but south of the creek the black hornblende rocks noted on Loon lake come into view and continue thence to the foot of the lake where a road falls in from the Addington road to an old lumber depot. Reddish granites here intersect the black hornblende in the area further west.

Green
chloritic
rocks.

The north-east portion of Abinger contains a large development of green chloritic rocks mixed with epidote in places, which, near the village of Vennachar, show a well banded structure with a strike of N. 70° E. and a dip to the north. The intrusive red granite is also here seen. The green rocks extend south from Vennachar through the Beebe settlement where they are associated with hornblende and mica-gneiss; and as this road approaches the Snow road, about two miles east of the village, the strike changes to S. 60° E. with a dip to the north-east. The limit of these black and green rocks, or their contact with the granite-gneiss, is in the unopened area east of Mazinaw lake and could not be definitely ascertained.

To the eastward, this belt continues through Miller and North and South Canonto townships to the Madawaska river, south-west of Calabogie lake; and at the High Fall, is well exposed. Here it underlies the

* Hence the name of the lake, which is a corrupted contraction of the Indian word for picture.

black hornblende gneiss, and limestone of the section, given by Murray in the Geol. of Can. 1863, pp 28-29.

Further south, in the township of Barrie, somewhat different features are presented. This township is intersected by numerous lakes, generally long and narrow, among which the principal are Long lake, which is an expansion of the Mississippi river, and Marble lake, intermediate between this and Mazinaw lake; while to the north of Long lake is the Mississagagon and in the eastern portion of the township are Sand lake, McClintock and Shawenegus lakes. South of Long lake is another long and narrow body of water, known as Gull lake, which lies along the southern border of Barrie and Clarendon townships, and which, flowing east by Gull creek, discharges into the Cross lakes and thence into the Mississippi river about three miles west of the Kingston and Pembroke railway. Lakes in Barrie.

Along the valley of Long and Mississagagon lakes the upper series of limestones and schists is well developed; but along Gull lake, for the greater part of its length a large development of the reddish granite-gneiss again appears, underlying the limestones. The northern limit of this gneiss area is a short distance south of Long lake, and the contact between the two series is to be seen on the Frontenac road between the Mississippi river and Gull creek, about one mile and a half south of the former. Southward, the older rock can be followed for some miles along this road into the township of Olden, and the belt has a breadth of nearly ten miles in this direction. Westward it extends into the townships of Kennebec and Kaladar beyond the limits of this map-sheet, while eastward it maintains a north-east direction, and though in places largely concealed by the green schist and diorite, reaches the overlying Palaeozoic rocks in the township of Pakenham, on the south side of the great Ottawa basin.

The granite-gneiss of the area is usually moderately coarse-grained with occasional bands of blackish tint, and from its position evidently underlies the series of limestones and schists of the Hastings division. The rock is particularly well developed around the shores of the Cross lakes below Gull lake, and here forms a broad development to the south and east, reaching the Kingston and Pembroke railway and extending into North and South Sherbrooke townships.

Further south again, in the township of South Sherbrooke, and Bathurst, another approximately parallel area of this granite-gneiss comes to view, and extends with several interruptions eastward through the southern parts of Lanark and Ramsay, reaching the Palaeozoic basin between Carleton Place and Almonte. The continuity of this

band is interrupted at various points by the overlying masses of the Hastings limestones, schists and upper gneiss.

Four areas of
granite-
gneiss.

It will be seen from a glance at the structure of this area, as developed by the mapping, that four distinct and roughly parallel areas of the underlying granite-gneiss traverse the district; or, if we assume the area in the Madawaska portion to represent two distinct bands, separated by the narrow arm-like belts of the newer rock, five of the underlying bands of granite-gneiss may be recognized. All these several areas are separated by a series of newer sediments consisting largely of gneiss and limestone, the former often quartzose with certain bands of true quartzite, schists of various kinds, &c., the whole of which has been invaded at many points by masses of diorite, diabase and granite, sometimes in the form of pegmatite, which are evidently later in date than the calcareous and quartzose beds which they penetrate. From the movements which have affected all these rocks, subsequent to their formation, a general conformity in strike is now apparent; but that they are also unconformable in certain portions of the area, or that the schists and limestone series are of later date than the older gneiss division, is manifest from the relations here and there seen. Thus sometimes there is an apparently fairly regular sequence above the fundamental rocks into the upper members of the newer series, through gneisses, limestones and schists; at other times the limestone occurs in bands intimately associated with the granite-gneiss; while occasionally the schists rest upon this lower rock. From the fact also that the lower gneiss is apparently of igneous origin, while the members of the upper series are of sedimentary character, or at least large portions of these may be assigned to this category, an unconformity may be assumed.

Sequence
of rocks.

THE NEWER LIMESTONE, SCHIST AND GNEISS SERIES, (HASTINGS).

Hastings
series.

In the earlier reports of Vennor it would appear that, at the time of his investigation, the views as to the exact relation of the lower gneiss and the limestone series were by no means clear. Thus, in the Report for 1866-69, Vennor included in his lowest series not only the lowest gneiss, but also a great thickness, aggregating a supposed volume of nearly 11,000 feet, of gneiss, schist, diorite and crystalline limestone, the latter in places containing graphite.

Views of
H. G. Vennor.

This view was however modified in the latest report on the district, 1876-77, in the manner named on page 277 of that volume, by restricting the lower member to the syenite or granite-gneiss without the

limestones. Without entering upon a sketch of the history of the various changes which were made from year to year, as his studies in this field progressed, which would be productive of but little benefit, we may here simply give the details of the structure of the several members of the upper series, as observed in the various synclinal folds occurring between the areas of the lower gneiss just described.

In the comparison of the various rocks found in these basins, as they may be called, it will be observed that there are certain features common to all; while in some cases, owing to a development of strata and consequent increased thickness of the upper members of the series, there occur marked points of difference. It has not yet been found possible in this area to distinguish several distinct horizons in the calcareous portions of the series, as was originally done in the Grenville district, and later attempted by Vennor in the area under consideration.

The volume of these newer rocks increases in a marked degree in the eastern half of the district; but here again much of the surface in the direction of the Ottawa, is occupied by the fossiliferous sediments of the Palaeozoic formations, which embrace all the divisions from the base of the Potsdam formation to the Trenton, so that the crystalline rocks of the upper division which have been frequently described under the name of the Hastings series, are almost entirely concealed for a distance of some miles before the Ottawa river is reached, near Arnprior. Similar rocks however reappear on the north side of that river and extend for many miles on the strike, in a northerly direction towards the height of land.

Overlap of the Palaeozoic.

It would therefore appear, from a study of these rocks over a wide area, that a basin-shaped depression in the lowest crystallines occurs along the valley of the Ottawa, the western margin of which can be found about 100 miles west of the city of Ottawa, and it extends thence south to the vicinity of Brockville on the St. Lawrence river. To the north of the Ottawa river the greatest depth of this basin is found in the direction of the Gatineau and Lièvre rivers on the former of which the upper limestones have a very considerable development and extend northward for over 100 miles.

In the area comprised in the north-west portion of the map-sheet under discussion, between the Bonnechère and the Madawaska rivers the limestone and associated gneiss are but slightly developed. The limestone appears on the former river near the foot of Golden lake which apparently marks its western development in this direction. This is a short distance north of the limit of the sheet. On the

Limestone of Golden lake.

Opango road, which traverses the northern portion of the townships of Brudenell and Sebastopol, the calcareous bands are occasionally seen but their outcrops are of small extent, though there are exposures of the underlying quartzose and garnetiferous gneiss, which rest upon the lower series.

Griffith and
Lyndoch.

Throughout much of the townships of Griffith and Lyndoch, the rocks are concealed by sand drift, and opportunities for the study of the underlying rocks are comparatively few; but along the Madawaska which traverses these townships they are seen in fairly good exposures. Here the limestone is found in small quantity and generally in narrow areas, which have a north-east strike, and in places are associated with bands of rusty and quartzose gneiss, similar to the rock associated with the limestone north of the Ottawa. The broadest band of the calcareous rocks seen on the upper portion of this stream is an extension northward of the area found in the central part of the township of Denbigh, where the limestone rests on the south upon a large mass of reddish gneiss, and the whole band with the hornblende rocks associated, has a breadth of several miles. It extends in an almost north direction along the valley of a creek which flows from several lakes to the south of Denbigh village into the Madawaska river, which it reaches at the north-east angle of the township. This band crosses the river, but is concealed on the north side by drift so that its development in this direction is unknown. A small irregular band of the limestone also occurs in the southern part of this township, but its course is to the west of north, as if it had been deflected by intrusive masses in its vicinity.

Denbigh.

Madawaska
to Dacre.

Along the road leading from the Madawaska to Dacre, from the crossing in Griffith, gneiss and granite are the prevailing rocks for the first half of the distance. Then a band of limestone comes in and follows the course of the road into the southern part of the township of Gratton, where it widens somewhat, and continues through the southern part of Brougham township, into Admaston. Beyond this, to the Ottawa river, the limestone becomes associated with hornblende gneiss, schist, and some granites, and these last have exercised metamorphic action on the calcareous portion of the series. Some of these granites are associated with masses of anorthosite in the extension of this area, as in the townships of Ross and Horton to the south of Portage du Fort, and on the eastern half of Calumet island, where the limestone is sometimes entirely cut off on the strike or deflected at sharp angles.

Crossing the line of section from this belt in a southeast direction, the areas of the limestone and associated newer rocks become gradually more in extensive proceeding eastward. The most important of these, as shown on the Madawaska River section, appears on the stream in the southeastern portion of the township of Matawatchan, and extends south-west across the north-west portion of Miller. This belt extends in a north-east course through the eastern part of the township of Brougham, crossing the Madawaska at the Mountain chute and rapids, where it has a breadth of over two miles, and continues into the south-west part of Admaston township.

In order to obtain as good a section as possible of the rocks across the central portion of this area, a traverse was made along the Madawaska river from the Palmer rapid, which is a short distance west of the limit of the sheet, to Calabogie lake, about twenty miles west of its junction with the Ottawa at Arnprior. This section is fairly complete, but there are certain portions where the rocks are concealed by drift.

Section on the Madawaska.

Beginning then at Palmer rapids, it can be said that while the Madawaska may be classed as among the rough streams, its downward navigation is comparatively easy. There are a number of rapids and falls but the portages are generally good and many of the rapids can be run with a large canoe.

The rocks at the Palmer are reddish and blackish-gray quartzose gneiss, having a general strike of N. 70° E. and a southerly dip. This is broken up by masses and dykes of a coarse red granite which holds bunches of quartz and in which the mica is black. This granite contains aggregates of black hornblende, and sometimes of pyroxene, the gneiss is in places garnetiferous. It rests upon the southern side of a granite-gneiss area which extends across from the area west of the Madawaska into Brudenell and Sebastopol townships. The portage past the Palmer is about half a mile long or by crossing a small island midway two short portages can be made.

The Palmer rapids.

From the foot of the Palmer, where the mineral corundum has been found, to Aumonds rapid which is a fourth of a mile east of the western line of Lyndoch, the banks are usually low and sandy. Hills of red gneiss rise on either side of the stream, from a fourth of a mile to one mile distant. Aumonds rapids are about a fourth of a mile in length. The rock is a hornblende granite-gneiss, in places very black, with vein-like strings of hornblende and with bands of grayish gneiss, the strike at this place being S. 70° E. with a southward

Aumonds rapids.

dip, the change in the strike being probably due to granite intrusions in the vicinity. The part of the river above this, to the Palmer, shows only three small ledges of reddish gneiss. Good farming lands lie along the south side of the river at this place, and a rough settlers' road extends from the Palmer rapid, where it crosses the river, to the village of Denbigh, by way of Wingle post-office.

Aumonds
bay

Below Aumonds rapids, where there is a portage of about 500 yards, ledges of coarse red granite appear, but with this exception, no rocks are seen on the river to Aumonds bay, about two miles distant. Here thin bands of crystalline limestone cross the river, and the rock is mixed with lumps of rusty gneiss and associated with gray quartzose gneiss and quartzite. Pyroxene also occurs here. The strike is N. 70° E., but the strata are much disturbed.

Snake rapids.

Below this to the Snake rapids the rock exposures are few. The shores are generally low and sandy for some distance inland. The Snake rapids are about three miles in length and consist of eight pitches with strong water all along. Most of these can be run with canoes, but the last three are very rough and are surmounted by short portages, the longest of which is 150 yards. The rocks all along are a grayish granite with much hornblende, and in places foliation is well defined. Certain portions of the rock here resemble an anorthosite. These are sometimes foliated but generally the strike of the foliation is too obscure for determination.

Veins of a hornblende-granite rock, with many crystals of hornblende, cut this granite, and quartz strings are common. Thence to the foot of the Snake rapids, which is at the old crossing of the Addington road, now abandoned because of the bridge having been burned some years ago, the rocks are mostly grayish and hornblende granite with some gneissic beds at the lower end.

On the old Addington road which is now closed for about five miles south of the river, as a wagon road, the only rocks seen between the river and the junction of the road from Denbigh to Wingle on the way to the Palmer, are granite and gneiss. The foliation is not always distinct, and the rock is often black or dark-gray from the presence of hornblende or black mica. No limestone appears along this track, but at the point where it turns off from the road west to Wingle, a strong band of crystalline limestone comes in with a strike a few degrees west of north. It could not be traced in the rough country northward but it may possibly be the same as that noted at Aumonds bay on the Madawaska river.

Below the burned bridge on the old Addington road, the rocks for Slate falls, the next two miles, to Slate falls, show mostly dark hornblende-gneiss with strings of quartz. Slate fall is on lot 12, range XII, Lyndoch. The rock at this place is generally fine-grained granite and gneiss, the strike of the latter at the foot of the falls being north and south, with a dip to the east $< 60^\circ$. The black colour of the gneiss is chiefly due to the presence of black biotite mica. There is a portage of 300 paces on the south side past the fall into a small bay, on the east side of which, resting on the gneiss, is a band of crystalline limestone, bluish-gray and banded like that of Arnprior and Renfrew. This rock is often coarsely crystalline and has patches of hornblende in the mass. The dip of the limestone is S. 80° E. $< 65^\circ$. This limestone extends along the river for a couple of hundred yards, below which the banks are low and sandy. Several small islands below the chute are also composed of the blue slaty limestone, associated with schist and gneiss on lot 10. Thence down past the chain of small islands, the current is strong and the shores show ledges of black hornblende and mica-gneiss with a dip to the east $< 40^\circ$ to 60° as far as the sharp bend on lot 7. Red granite also shows along this part of the river.

Limestone again comes in at a bluff near the bend on lot 5. It strikes Griffith. N. 20° E. $< 80^\circ$ and shows at intervals along the shores to lot 2, forming the rapids past the three islands to the town line of Griffith. This is the northeast extension apparently of the limestone area already noted in the township of Denbigh, which here crosses the Madawaska into the township of Griffith, and is there probably concealed largely by sand drift. The band of limestone exposed at this place is about three fourths of a mile broad, and the rock is similar in all respects to the typical Hastings limestone of Lanark and other places to the south. Much of the associated gneiss is a dark gray and rusty rock similar to that seen about Sharbot lake. It is frequently cut by granite dykes.

Midway between the west line of Griffith and Hyland creek, a Hyland chute. small band of limestone crosses the river associated with gneiss and some granite. From this down to Hyland chute the rock is mostly a black biotite gneiss very rusty in places and decomposing readily. It dips S. 40° E. and the small falls at this place are upon it. The rock is generally black, composed of quartz, feldspar and black mica; and is in places very pyritiferous. It is cut by small veins of granite and quartz, the latter occurring in strings and irregular bunches. Masses of dark-gray granite intersect the gneiss, and have twisted the stratification in all directions.

The portage past Hyland chute is 250 paces long and at the lower end there is a band of gray crystalline limestone associated with the rusty dark gneiss, the strike of the series being N.E. with a southeast dip of 75°. These rocks have pyritous bands and decompose readily, resembling in this respect the rocks along the Kingston and Pembroke railway, north of Sharbot lake. From Hyland chute down to the Griffith bridge the shores are generally flat. Heavy masses of reddish granite show on the south side of the river near the bridge which is at Hyland chute, and from this point the road from Denbigh goes across to Dacre. Much of the granite about this place is reddish but there are also black bands which resemble a coarse hornblende diorite.

From this down to the first rapids, at Campbells mills, the rocks, where seen, are mostly a reddish granite-gneiss. Along the roads to the south of the river this rock is seen at a number of places, and it appears to constitute a somewhat broad belt which comes across from the township of Denbigh at Eagle Hill.

Campbells
chute.

At the mill and chute, there is a portage of 430 paces over dark-green hornblende rocks with some limestone in thin bands. The hornblende rock has the aspect of a diorite in places and the limestones are much shattered. This fall is called Campbells chute.

Below this, the road on the south side keeps near the river for several miles to the ferry which leads across into the township of Brougham. At the Wolf rapids and chute, which are about two miles west of the ferry, the rock is a blackish hornblende gneiss like that of Sharbot lake, holding very pyritous and rusty bands, with a strike of N. 30° E. and a high dip to the south-east. The gneiss of this area is nearly all black and hornblendic, with grayish, and sometimes reddish, bands.

Wolf chute.

From Wolf chute to the ferry the rock is nearly all gneiss, but just west of the ferry, bands of limestone come in. This rock shows thence at intervals to the head of the island above the Colton chute, where the rusty gneiss again appears and forms a chain across the river with a strike N. 40° E. dip S. 50° E. < 65°. This gneiss is black with irregular bands of gray granite cutting it.

Colton chute.

Colton chute is a rough pitch over rusty black hornblende-gneiss along with grayish bands. The ingredients are coarsely granular and the rock has a clastic aspect. The lower part of the Colton chute passes over coarsely crystalline limestone, with bunches of quartz, interstratified with grayish quartz layers; dip S. E. < 75°. At another chute a fourth of a mile below the main Colton, the rusty blackish-gray

gneiss appears, with bands of very coarsely crystalline limestone and masses of granite. Along the river the granites are generally fine-grained and reddish-gray.

Thence down for several miles, the river bank on the south side shows limestone, having a strike along the course of the stream which, is here about N. 60° E., and on the upper half of this stretch, the gneiss forms the north side of the river. The north side, to the point where the river turns sharply to the south, is mostly hilly and composed of granite and gneiss, while the limestone which shows along the south side forms the northern margin of a broad belt already described as extending from Miller to Admaston, in the course of which, to the northeast, it skirts the road extending west from Mount St. Patrick corner to Black Donald post-office in Brougham and forms a continuous band for at least fifteen miles.

The band of limestone which here comes to the Madawaska river is continuously exposed along the stream for several miles. It appears along the shore at different points to the big island at the head of the Chain rapids, and in places is tremolitic and cut by granite. The dip at the island is S. 60° E. Occasional bands of gray gneiss come in with the limestone to the next rapid at the foot of the island which is called the Cedars, and thence, to the head of the Mountain chute, the rock is nearly all limestone.

The Mountain chute is a very rough part of the river. The portage past it is 1,450 paces long over limestone all the way, and there are numerous heavy pitches which are apparently caused by dykes of reddish granite which intersect this rock. The strike of the limestone varies from N. 50° to 60° E. and the dip is generally at a low angle to the south. Below the Norway rapid, which is a short distance from the Mountain, the limestone still continues, the rock having much quartz in strings and bunches, but is otherwise the same bluish striped gray rock of the Hastings series, which is so common in the calcareous portion of that division.

Limestone continues along the river to the entrance to Mud lake, which is on the south side, about one mile below Norway chute. Here it is associated with thin bands of the rusty hornblende gneiss, and the bands of limestone and gneiss are in frequent alterations. A short distance below this the reddish gneiss and granite again appear on the south side of the river and continue almost without interruption to the High falls, which is just above the entrance of the river into Calabogie lake. Several bands of limestone however show in the vicinity; and below the falls, beds of the black hornblende-gneiss, in

places schistose, come in and form the rocks around the western and southern side of this lake. This is the place where Murray made his section in 1857, which is given in "Geology of Canada, 1863," pages 29-30.

Mud lake.

On the shores of Mud lake, just mentioned, which extend for several miles south from the line of the river, the rocks are largely granitic. Two small bands of limestone show along the east side, but near the upper or south end, the granites assume more the aspect of the oldest type, and the country to the south, in the direction of the Trout lakes in Canonto, appears to be very rough and composed largely of granite. There are no roads traversing this area, which is entirely unsettled, so that there appears to be a broad belt of the granite-gneiss between the limestone of the Madawaska, just described, and the belt which extends northeast from Barrie through Miller and the northern part of Palmerston, and which may be styled the third parallel belt of the upper series.

Calabogie
lake to
Arnprior.

On the portion of the Madawaska between Calabogie lake and the Ottawa river at Arnprior bluish-gray the striped limestones are well exposed below the outlet of the lake. Around the lake itself the rocks are largely schistose and hornblendic, with bands of limestone. Near the village of Springtown a band of coarse red granite, which is evidently newer than the limestone, comes to the surface and forms a considerable area between the Madawaska and the Kingston and Pembroke railway. This granite cuts the limestone and mica schist, and in the vicinity the former is very tremolitic. East of Burnstown, which is about seven miles to the south of the town of Renfrew the limestones, are the predominating rocks till they become concealed by drift and clay near the town of Arnprior, or are covered by the limestones of the Calciferous and Black River formations.

To the south west of the Madawaska river near Arnprior these bluish striped limestones have a wide development. They are especially well exposed to the north and east of White lake which crosses over into the township of Darling, and the breadth of the limestone in this direction is not far from eight miles across the strike. To the west of the area in the townships of Darling, Bagot and Lavant its volume is largely reduced and the principal rocks are schists, both micaceous and hornblendic, along with minor bands of reddish-gray gneiss which are especially well seen along the line of the Kingston and Pembroke railway north of Lavant station and thence to the town of Renfrew.

This band of schist and limestone with grayish and black gneiss is one of the most important in the whole area. It can be traced continuously from the western limit of the sheet in Anglesea and Barrie where it forms a well defined synclinal between the gneiss of Mazinaw lake on the north and of Gull lake on the south. The strike of the limestone and gneiss, west of the railway, is very uniform, with the exception of a few local twists and has a direction a little north of east or about N. 60° E. On the north of this basin the dip is to the south-east while on the south side of Long lake the dip becomes reversed to the north-west. The limestone is especially well seen along the shores and islands of Long lake and in that part of the Mississippi below this almost to Cross lake beyond the eastern line of Clarendon township. The limestone in places is blue and slaty, resembling in aspect some of the limestones of the Cambro Silurian of the southern part of Quebec near Lake Memphremagog: but this rock assumes a highly crystalline character as it approaches the masses of intrusive granite or diorite. In places also the limestone is filled with quartz in the form of irregular strings and bunches, which give the mass a very ragged aspect on weathered surfaces, and form a feature easily recognized at many points throughout the distribution of this portion of the formation.

Schist and limestone.

Long lake
Mississippi
river.

Another important area of the newer rocks of the Hastings division is that which appears in the southern part of the map-sheet, in the townships of Olden and Oso, at Sharbot lake. This area is bounded on the north side by the old gneiss of the Gull Lake belt and on the south by the similar rock which comes in between Sharbot lake and Bobs lake. It extends northeast through the townships of North and South Sherbrooke, and occupies the southern portion of the township of Dalhousie and the northern part of Bathurst, as well as a large portion of Lanark, continuing on into Ramsay where it is concealed by the overlying Palaeozoic formations, here represented by the Potsdam sandstone and the Calciferous dolomite. In Dalhousie and Lavant townships, the limestones of this area are separated from those of the belt just described, by a great development of greenish dioritic and diabase rocks, and also by large masses of reddish granite, in which there are often but slight traces of foliation. In Bathurst the southern limit of these limestones is marked by Lake Bennett, which is an expansion, about five miles long, of Fall brook, a branch of the Mississippi river. The road east from Elphin corner to McDonalds corner, and thence south-east to Fall brook post-office, traverses this limestone belt for about eight miles. The limestones are the usual crystalline striped or banded variety, often holding veins and bunches of quartz with occa-

Sharbot lake
east.

Lake
Bennett.

sional bands of black hornblende and schistose gneiss, and sometimes with masses of granite. In the eastern part of the township of Lanark the limestone has a breadth of fully six miles and is terminated on the north by the red granite-gneiss of the western part of Pakenham which divides the area from the limestone of the White Lake belt.

In this area the schists are not so well developed as in the Lavant region, which may therefore possibly represent a greater development of the upper members of the series. Sometimes the limestone bands are broad and continuous for a long distance, but at other times their continuity is broken, either by thinning out, or by the sudden termination of the bands by intrusive masses.

Barrie and
Clarendon.

The newer aspect of these rocks is well seen in the townships of Barrie and Clarendon, which are traversed by the Mississippi river, from the foot of Mazinaw lake into Palmerston. This stream, while flowing for a good portion of the distance somewhat along the line of the strike, affords a fairly good line of section. Beginning at the crossing of the Kingston and Pembroke railway, near the Snow road station, the several varieties of rock outcrops there found, with their relations, may be here described.

Section on the
Mississippi
river.

The lower part from the railway bridge westward is in a reddish granite-gneiss, sometimes tinged with green, and with masses of red granite, apparently intrusive in character. The gneiss strikes generally N. 30° - 50° E. and dips S. E. $< 20^{\circ}$ - 50° . These rocks are well exposed at Millers chute, about one mile above the railway bridge, where also bands of chloritic, epidotic and hornblendic rocks are associated. In places these rocks are schistose. From this point upward to the Ragged chute, which is a very rough part of the river along which a portage road of 1,200 paces extends, the rocks are largely a reddish gneiss or granite. At the Ragged chute, a band of white or cream-coloured limestone comes in, holding small inclusions of rusty gneiss, the whole being cut by dykes of white pegmatite. The limestone dips S. 40° E. $< 20^{\circ}$ and resembles much of that seen in the limestones of the Grenville series. Above this to the next chute, about 600 yards, distant, the rocks are again the red foliated granite-gneiss, the strike of which is N. 60° E. with a dip to the south-east. This same rock extends up to Kings chute where there is a portage of 370 paces over roughly foliated red granite, composed largely of red feldspar, quartz and black mica, and this rock continues upward to the foot of Croche or Cross lake where the strike of the foliation is N. 60° - 80° W. with a dip to N. 30° E. $< 15^{\circ}$ - 20° . The trail past the chute at the foot of the lake is 100 paces in length.

Ragged chute.

At the bend of the lake shore a fourth of a mile above the dam, the strike of the foliation changes to N. 40° E. with a south-east dip, and the gneiss is cut by dykes of red pegmatite. In character this rock resembles much of that styled, in the former reports, the Ottawa gneiss.

Croche or Cross lake consists of two parts connected by a creek ^{Croche lakes,} nearly half a mile in length. The more southerly receives the waters of Gull lake, already referred to, by a creek about four miles in length. The reddish foliated granite gneiss extends along the entire shores of the two Croche lakes, as also along the shores of Gull lake. In the latter area the red gneiss contains bands of black hornblende mica-gneiss, which in places weathers rusty; but no trace of limestone or garnetiferous gneiss was noticed in this direction. The strike of the rocks on Gull lake, as also on the upper Croche lake, is about N. 70° E. the dip being S. 20° E. < 40°. Dykes of coarse red granite are frequent and the rocks as a whole present features very like those seen in the area to the west already described.

On the lower Croche lake the red gneiss extends all around the ^{Granite} shores to the inlet of the Mississippi river, or head of the lake. The ^{gneiss.} strike and the dips are similar to those just given, but they sometimes vary a few degrees. Just above the lake on the Mississippi, the granite-gneiss is succeeded by a greenish and fine grained schistose gneiss, which weathers rough and nodular. The dip is S. 55° E. < 50° and the rock contains irregular quartz veins. The rock sometimes becomes schistose and this schistose character is seen as far up as the wing-dam, from which point a rough road leads off north to the village of Ompah. The dip here is N. 20° W. < 80°, and masses of fine grained granite are associated with the schist. Just above the wing dam, heavy beds of rusty dolomite appear, in places with much quartz in the form of strings and bunches, and this overlies the schist. This point apparently marks the southern limit of the dolomite and schist series of the Clarendon belt.

From this place to the bridge over the river on the road leading ^{Dolomite.} from Ompah to Ardoch, the principal rock outcrops are brownish or orange-coloured dolomite and dolomite schist. Above this to the second bridge at Ardoch, the hills on both sides of the river expansion known as Mud lake, also show frequent exposures of the ochreous-weathering dolomite. The rock in mass is sometimes pinkish-coloured but more generally has a yellowish tint. The islands in this lake are also largely composed of the same dolomite, but at the point at the lower portion of the bay, below Buckshot creek, and about one mile

below Ardoch bridge, well bedded hornblende and mica schist come in, certain bands of which are studded with garnets. Veins and strings of quartz run along the bedding planes of this rock, and these are sometimes rusty and pyritous. The dip of the schists is S.E. $< 70^\circ$. They underlie the dolomites of Mud lake and continue to Ardoch, where the dip changes to S. 30° E. $< 70^\circ$.

The old Frontenac road crosses the river at this point and continues north-west to the village of Plevna, about five miles distant. On this road the limestones are associated with bands of black hornblende schist or schistose diorite for several miles. Their distribution in this direction will be referred to later.

Ardoch and
Plevna.
Gold.

South of Ardoch bridge the dolomites extend for about one mile and a half till they meet the mass of the Gull lake granite.

In the area between Ardoch and Plevna there are several gold mining locations. The gold occurs in connection with black hornblende rocks which traverse the limestones, along with bands of reddish gneiss. At certain points dykes of dark diorite also come in and veins of quartz occur, some of which are gold-bearing and have been opened.

West of Ardoch, the shores of the Mississippi show ledges of dolomite and dolomitic schist which continue into Long lake, another expansion of the stream. At the first chute, a mile above the Ardoch bridge, these dip N. 35° W. $< 75^\circ$. The carry here is 130 paces long. Above this the river widens into a lake with several islands, on which the dolomite is the principal rock, and then continues to a second pitch or series of small chutes, past which there is a portage of 500 yards to the foot of Long lake.

Long lake.

The dolomites along this part of the river are, on fresh surfaces, hard and fine-grained. They weather brownish and have partings of calcite and bitter-spar. At the foot of Long lake, the dip is reversed to S. 20° E. $< 50^\circ$ and the rock contains strings of black hornblende. The cream-coloured dolomites are associated with hard siliceous bands and underlaid on the north side by a belt of reddish granite-gneiss, and the limestone at some points is much distorted.

Long lake is about twelve miles in length and the dolomites are exposed for the entire distance along the south shore, where they are sometimes changed to a highly crystalline saccharoidal cream-coloured rock. This is more particularly seen near the contact with a mass of granite-gneiss. The strike along this portion of the lake is N. 60° E. and the dip is N. 30° W. $< 40^\circ$ - 50° , but on the north shore the rock is often much less altered and frequently presents the aspect of a bluish

slaty limestone which contains mica. This feature is especially well seen on the road which extends along the north side of the lake from Ardoch to Myers cove post-office, which is at the foot of Marble lake. The limestone is here associated with bands of black hornblende, sometimes schistose rock, and these are cut by dykes of granite.

From the upper end of Long lake an old portage route leads across to the upper bay on Gull lake to the south. This route is now abandoned, but it was followed for some distance. The limestone of the lake shore was seen to rest against a belt of hornblende, sometimes gneissic rock with a dip to N.W. $< 75^\circ$ which was in turn underlaid by the reddish granite-gneiss of Gull lake.

At the narrows of Long lake which is near the upper end, the slaty, and somewhat schistose limestones, are much disturbed and sharply folded. The limestone continues to the west end of the lake which here widens out into a deep bay, and from this extends west in the direction of the Addington road towards Cloyne.

The lake here turns sharply to the north and following up the river for half a mile, a rapid with a portage of 100 yards connects with Whitefish lake silver mine. At this rapid several pits have been sunk, in the attempt to mine silver-bearing galena near the contact of the limestone with granite dykes. The blue character of the limestone suddenly gives place near the contact, to a highly crystalline condition and the rock becomes a marble. But small trace of lead ore is seen in these rocks at this point, though the rock is somewhat cavernous. This is Myers Cave mine. The rocks strike generally N. 60° E. in a nearly vertical attitude. Similar associations of the limestones and slaty schists show around Whitefish lake to the foot of the chute at the outlet of Marble lake, on which there is a sawmill; and the road from Ardoch to Myers Cave post-office, here crosses. Here hard bluish-gray slaty and micaceous rocks cause a fall of about 20 feet, and the limestone in the vicinity is highly crystalline. The strike is N. 65° E. and the dip vertical, and just above the dam a great mass of hornblende diorite rock comes in on the west side which is apparently intrusive in the limestone. The Helena copper and gold mine is situated on the east side of the lake on lots 19 and 20, R. VI and lot 20, R. VII, Barrie. The Helena mine.

In Marble lake the south shore of the main bay is occupied by green Marble lake, slaty schist sometimes highly micaceous, which is similar to that seen on the road south from Cloyne to Kaladar. With this are associated dolomites and dolomitic schist, the dip of which is N. 35° W $< 80^\circ$. Above this to the head of the lake, or to the foot of Mazinaw lake, there is considerable development of the crystalline dolomite or marble

which shows on the western shore and in the river above, and from which the lake takes its name. The rocks of Mazinaw lake have already been described on a preceding page. The black hornblende bands come in between the marble of this lake and the reddish gneiss.

The synclinal structure of the Long lake area is thus well established by the dips on either side, and the metamorphic action of the diorites and granite is clearly seen at a number of places. The same features appear in connection with similar blue slaty limestones of this series, further east in the township of Lanark, which will be referred to later.

Lake
Missasagagon. To the north of Long lake, on the Mississippi, lies Missasagagon lake. It discharges into Buckshot creek, a tributary of the Mississippi, by Swamp creek, and is long and narrow. The west end of the lake is reached by a portage of half a mile from the foot of Marble lake and shows beds of limestone, with interstratified bands of black hornblende gneiss, the rocks being the eastern extension of those seen on Marble lake. The north side of Lake Missasagagon is occupied for the most part by the blue slaty limestone, much twisted in places and resembling the beds seen on Long lake to the south. The dip of these is generally north-west at a high angle. Near the east end of the lake a portage road leads across to another chain of lakes, among which are McClintock's and Sand lakes. The portage is 1,200 paces long and the limestones extends for 700 paces to a band of black hornblende rock similar to that seen on the north side of Gull lake. This has a breadth of about 100 yards and rests upon the reddish granite-gneiss which extends from Mazinaw lake and which, further east, crosses the Snow road about three miles north of Plevna village. The islands in this lake, as well as the south shore, are mostly composed of the blue slaty limestone with bands of black hornblende rock, and with diorite masses. Between this lake and Long lake on the road from Ardoch to Perry, on lot 13, range VIII, Barrie, a silver mine was some years ago opened which disclosed rich ore and was worked to some extent, but the property became involved in litigation and work has long since been abandoned. The rocks at the mine are limestone with mica and hornblende schist and the ore is argentiferous galena.

ver mine
Barrie.

This road, from Ardoch west, along the north side of Long lake to Myers Cave runs for the greater part of the distance over the slaty limestone. With this are bands of black hornblende schist, the dip being generally N. 30° W. < 40°-60°. An occasional reverse dip to the south east is seen in these rocks near the head of Long lake, but the strike of the series is very uniform.

From Myers Cave post office, at the foot of Marble lake, a road south passes by the end of Long lake and extends to the line road to Harlowe and to the head of Gull lake. On this road the limestones extend past the south-west bay of Long lake and are generally highly metamorphosed. They are met in this direction by granitic and amphibolite schistose rocks, the latter being sometimes greenish coloured, and often massive, with a marked dioritic aspect in many places. The surfaces often weather rough and nodular, giving the rock at times a coarsely conglomeratic appearance. Occasional bands of dolomite occur with the greenish schist portion. These continue south to the Harlowe road, which extends east from the corner on lots 26-27, between ranges II and III, Barrie. On the south side of this range line road, hills of black hornblende rock, sometimes schistose, appear, overlying the reddish granite gneiss ridges to the south, which thence continue along the course of Gull lake and out to the line of the Kingston and Pembroke railway.

Long lake
to Harlowe.

These rocks are similar to those seen on the Addington road, south of Cloyne post-office. In places they strongly resemble eruptive rock, being massive and sometimes porphyritic; at other places they present the appearance of true hornblende, chlorite or mica schist. On a road leading out from this corner to the Addington road which it reaches about a mile and a half south of Cloyne post-office, a broad belt of well banded limestone comes in, which is evidently the western extension of the Long lake band, but which is apparently terminated somewhat abruptly before reaching the Addington road by a mass of green diorite, with granite, which is there well developed, since the only traces of the limestone seen in that direction are certain narrow bands of dolomite.

A section of the rocks seen along the old Frontenac road which extends from Mountain Grove station on the Canadian Pacific railway, across the country north to the Madawaska river, shows the structure of this basin in considerable detail. The southern portion is largely composed of granite and gneiss, and the contact with the rocks of the overlying series is about two miles south of the bridge across the Mississippi river at Ardoch. Here the lower or hornblende portion of the series comes in and is shortly overlain by the ochreous dolomites. This is near the road which turns off east to Green lake, along which also the dolomites are well exposed. The dip of the reddish granite-gneiss at the contact is N. 30° W. Thence to near the river the dolomites dip regularly to the north-west. Near the Ardoch bridge, bands of hornblende rocks with some red gneiss, and granite dykes are

Old Frontenac
road.

Contact near
Ardoch.

interstratified. Just north of the bridge a band of the hornblende schist comes in, reaching nearly to the forks of the road which passes by Long lake. Then limestones, sometimes blue and slaty, at other times highly crystalline, extend for several hundred yards. About three-fourths of a mile north of the forks of the roads the dip is reversed to S. 30° E. < 80° and the hornblende rocks become more widely developed; but the limestone again appears in a broad belt which extends along the Plevna road to a point half a mile north of Swamp creek, the south-east dip being maintained at angles of 50° - 60°. Here it is overlain by a band of hornblende granite-gneiss, with a breadth of about two miles, which extends to within half a mile of Plevna post-office. This is overlain by a broad area of crystalline limestone which in places is blue and slaty, and which is exposed along the roads to Plevna and north of that village as far as Tooley's stopping place on the Snow road. It is also well exposed along a road which extends west of Plevna to the town line of Barrie. This band shows a well defined synclinal structure, the dips near Plevna being north-west < 80°, while near the north limit of the area this is reversed to south east. Associated with the limestone are bands of hornblende and mica schist, and the basin of newer rocks is terminated northward by the underlying mass of reddish granite-gneiss of the Mazinaw belt. This granite area extends along the Snow road for a couple of miles, beyond which, in this direction, a second basin-shaped area of greenish hornblende schist and allied rocks continues to Douglas's house, where the portage between the Brulé and Buckshot lakes crosses the main road. This band is narrow, and the granitic gneiss again comes in and extends to the eastern line of the township of Abinger, the western limit of which is seen near the forks of the road at Mallory hill. This belt of the granitic gneiss shows an anticline and is, at this place, overlain by another broad belt of the schists which occupies the north-east portion of Abinger and extends to the corner at Vennacher, already alluded to, and which is apparently the western extension of the belt of schist and limestone seen on the Madawaska river which it crosses at Mountain chute. This area of schists apparently terminates in the rough country between this road and the head of Mazinaw lake.

Snow road
west of
Plevna.

Vennacher.

Snow road
east of
Plevna.

Eastward of Plevna, the Snow road continues through the eastern half of the township of Clarendon and across Palmerston, till it meets the Kingston and Pembroke railway north of the Mississippi river bridge. This road, for more than twelve miles, or to a point several miles east of the village of Ompah, traverses almost continuously a broad band of crystalline limestone. In places this is highly altered, the rock containing much quartz in strings and bunches, which gives

a very ragged surface when weathered. The strike is uniformly N. Ompah. 60° E., and the dip is for the most part to the north-west, though this changes about one mile west of Ompah to south east < 50°. Near this village the limestone is associated with bands of greenish rusty schist, some of which, across the strike, have a breadth of 300 to 400 yards.

A road turns off south from the Snow road about one mile west of Ompah and crosses the Mississippi river which is nearly four miles distant to the south. Along this road the rocks are mostly limestone with occasional bands of schist, and about one mile north of the river, bands of slaty conglomerate, with quartz pebbles, appear, which are similar to the conglomerates noted in Kaladar, south of Cloyne. They have also been observed at several intermediate points and thus appear to be fairly persistent. The pebbles in this conglomerate are drawn out in the direction of the planes of the bedding. They were observed also along another road which extends south of Ompah corner towards Mississippi river.

This broad band of limestone is also well displayed along a road which traverses the area north of Mud lake (Mississippi river) which extends from the Ardoch-Plevna road to the road south from Ompah near the second bridge. Here dolomites and striped limestone are almost constantly exposed for nearly four miles diagonally across the strike, and the rocks show the presence of several folds. Near the eastern end of this road the limestone bands are interstratified with schists and hornblende rocks. These rocks are the western prolongation of a broad area of schists, limestones and hornblende rocks, which are well developed in the townships of Lavant, Darling and Bagot, and which thence reach the Ottawa near the town of Arnprior, where the limestones have a still wider development and extend over portions of MacNab and Pakenham townships.

The north east corner of the township of Palmerston is traversed by several roads. Of these, one extends from Lavant station on the Kingston and Pembroke railway to the junction of the Snow road which comes up from the Mississippi river, at a point about three and a half miles west of the station. On both these roads the limestones of this series are well exposed, but the bands are somewhat narrower and the schists and upper gneisses are more extensively developed. They are frequently cut by dykes of granite and by diorites.

On the road west from Lavant station, the strike of the limestones and schists varies from N. 30° to 60° E. and the dip is to the south-east < 25° to 50°, but on the road from Snow road station to this road

several flat-lying folds are seen in brownish and rusty schistose gneiss with dips of five to ten degrees.

Ompah to
Folger
station.

On several roads north of the Snow road the rocks are less calcareous and the schists and red granites more exposed. One of these roads extends from a short distance east of Ompah, by way of Trout lake, to Folger station. Near the crossing the Clyde river, west of the railway, chloritic and epidotic rocks are well displayed. The road east of Ompah past Trout lake, shows varying strata of schist and limestone, the dip of which is uniformly to the south-east, and the same prevailing dip is seen on a couple of cross roads which connect this with the Snow road.

Trout lake.

The north side of Trout lake, which is traversed by the township line of Palmerston and South Canonto, apparently marks the northern limit of this limestone area. North of this, to the Madawaska river, the rocks more closely resemble the underlying granite-gneiss series, with which are occasional bands of hornblende rock with some thin limestones, but the red granite apparently occupies the greater portion of the township of Canonto, the surface being rough and hilly and unopened by roads, to the limestone belt indicated on the Madawaska section at Mud lake.

Miller
township.

In the township of Miller, several large lakes are found. Among these may be mentioned Buckshot, Brulé, Fortune, Skeads and the Schooner lakes. Lake Buckshot discharges into the Mississippi near the village of Ardoch, but the others flow into the Madawaska by way of Skeads and Mackay creeks. This last enters the Madawaska river about a fourth of a mile below the Colton chute, and a very fair section is presented across the township.

Schooner
lake.

Ascending from the Madawaska river by Mackays creek, the limestones, which are in places highly tremolitic, extend for about half a mile. Then a band of hornblende gneiss comes in, of about the same breadth, above which mixed limestone and gneiss extend to the outlet of Schooner lake, the calcareous rocks largely predominating. Heavy dykes of whitish pegmatite cut the rocks of the series, and at the entrance to the lake the dip of the limestone is N. 40° W. The strike of the underlying reddish granite-gneiss, which is sometimes well foliated, but at other places massive, is about N. 20° W. < 40°. The limestone at this locality is also tremolitic and in parts filled with bunches and strings of quartz with occasional irregular bands of rusty gneiss, resembling in this respect much of the Grenville limestone. The limestone at the outlet of Schooner lake marks the south side of the belt which crosses the Madawaska river at the Mountain chute.

Around Schooner lake the rocks are mostly reddish gneiss, which is cut by dykes of granite, often fine-grained. At the narrows connecting with the next or Skeads lake a band of very coarsely crystalline limestone appears with bunches of white quartz, and this is cut by a heavy dyke of red granite, 50 feet wide, which is evidently more recent than the limestone. The latter rock occupies the greater part of the north shore of the second lake, and at the upper end a creek and short portage leads into Mackays lake. The south shore of Skeads or second lake is occupied largely by the red granite-gneiss, and the same rock occupies the greater part of the shores around Mackays lake. The strike of all these rocks is about N. 70° E. and the dip N. 20° W. < 20°-40°. Much of the granite, however, shows but small traces of foliation.

From the outlet of Schooner lake, a route by way of Skeads creek leads to Fortune lake, and the limestone is exposed at intervals all the way. On Fortune lake the limestone occupies the north side and the greater part of the west shore. It is cut by many dykes of the red granite. On the east side of the lake exposures are fewer, but hills of the granite rise in the direction of Mackays lake and masses of the black hornblende rock come in. This rock is well seen on the southern end of Fortune lake, and extends across to the northern end of Brulé lake, but a band of limestone comes in along the connecting creek and extends along the north end of the latter, reaching the old Frontenac road which crosses from the Snow road into Metawatchan township, and thence to the Madawaska river. On this road the limestone and schist are underlain by the reddish granite and black hornblende gneiss, which form most of the shores of Brulé lake. The dip of these rocks where seen is N. 20° W. < 20°-50°.

Further east along the line of the Kingston and Pembroke railway a good section is afforded, both of the upper and of portions of the lower gneiss. This section extends from Sharbot lake, which is on the southern margin of the map-sheet, to Renfrew which is just at the northern margin. The railway, for a considerable part of this distance, follows along the strike, or cuts this diagonally; but shows the relations of the two series at a number of places. The rocks between Clarendon station and Calabogie are of economic importance since in this part of the area some of the largest and most valuable of the iron ore deposits of this district are situated.

Sharbot lake, which lies just south of the map-sheet, is divided into two parts, the connection being by a narrow creek, across which both

the Canadian Pacific railway bridge and the highway road crosses. The rocks in both lakes comprise areas of crystalline limestone associated with bands of black hornblende gneiss and schist along with red granites and gneiss. The latter feature is more especially seen in the eastern portion of the east lake, while the black hornblende schistose gneiss is better developed near the narrows between the two. The narrow point between the lakes is composed principally of crystalline limestone, with a dip S. 50° E. $< 35^{\circ}$ - 40° . This is cut by dykes of granitic rock which have disturbed the original bedding of the limestone. The rock is generally coarsely crystalline, but often banded or striped, like that of Renfrew and Arnprior. At the east end of the railway bridge there is a cutting in reddish-gray micaceous gneiss, well foliated, and with partings of thin bedded shaly gneiss, the dip of which conforms with the limestone near the station. South of this along the railway (K. and P.) there is a succession of hornblende schists and gneiss, cut by dykes of red granite for several miles, having a uniform south-east dip $< 40^{\circ}$ - 70° to near George lake where they are overlain by crystalline limestones which apparently conform in dip with the underlying schistose gneiss.

Around the shores of west Sharbot lake, the principal rock exposures are blackish hornblende schistose gneiss. This is often much decomposed and on weathered surfaces is generally very rusty. In places these rocks are cut by black coarse hornblende diorite; but a band of limestone extends in a curving outline through the centre of the lake and shows on the south side of the long point at the western extremity, as well as on several of the islands intermediate between the foot of the lake and this point. The strike at the west end of the lake is east and west with a south dip $< 45^{\circ}$, so that the limestone is apparently an interstratified portion of the hornblende schists of this locality.

Along the line of the Kingston and Pembroke railway, north of this place, the strike changes to a more northerly direction, and in the limestone and rusty rocks, at a distance of a mile north of the station, is nearly north and south, dipping east $< 20^{\circ}$. Near the first road crossing on the railway the dip again swings round to S. 40° E. $< 35^{\circ}$; but, between this and Oso station, the limestone and schist are apparently cut by masses of red granite, and the strike varies from N. E. to N.W., the dip being however easterly in both cases.

Oso to
Clarendon.

From Oso station to Clarendon station, ledges of crystalline limestone are frequent and cuttings in this rock are seen at intervals for the greater part of the distance. The limestones frequently present

the banded aspect so common to the limestones of the Hastings series, and dykes of reddish granite are common. Along this part of the section the dips are very uniformly to the south-east and vary from S. 30° – 55° E. $< 40^{\circ}$ – 50° , but at one point about midway, near a mass of blackish diorite, the dip swings round to S. 10° W. $< 45^{\circ}$, though the strike speedily changes again to the normal direction of N. 60° E. Near Clarendon station, and for nearly a mile and a half south of that point, masses of hornblende gneiss and granite occur with several minor bands of limestone.

The seemingly broad band of limestone noted on this portion of the section north of Oso station does not appear to extend far to the east. It is terminated in this direction apparently by masses of red granite and by hornblende or amphibolite rocks which form large areas between the railway and the western line of the townships of North and South Sherbrooke, but the limestone band of Sharbot lake extends continuously into South Sherbrooke, and further east it occupies a large portion of the southern half of Dalhousie, nearly the whole of Lanark, and the northern part of Ramsay, till it is concealed by the Palaeozoic rocks of the Ottawa basin east of the Mississippi river.

Between Clarendon and Snow road station, which is a short distance north of the crossing of the Mississippi river, the limestone outcrops are few. The rocks are mostly red granite, sometimes gneissic, with masses of black or dark green diorite, and near Mississippi station, bands of hornblende schist. At this last place a band of limestone crosses the railway with a dip of S. 55° E. $< 30^{\circ}$, which contains much quartz, and this continues on the strike across the river into the northern part of the township of North Sherbrooke, where it is cut off by masses of intrusive granite and diorite. The limestones at this place are much altered. They are invaded in all directions by the intrusive rocks which sometimes cut them off on their strike, and sometimes contain masses of the limestone as if caught up in the diorite mass. The limestones are also filled with bunches and masses of quartz. The Robertsville iron mine occurs a short distance east of the railway at Robertsville station. Clarendon to Snow road.

Between Mississippi station and the Mississippi river the rocks are mostly red granites, sometimes massive, but occasionally well foliated; but north of the river, in the vicinity of Snow road station, beds of hornblende and mica schist come in. These are cut by dykes of red granite and by masses of the same rock. The strike of the foliation in the granite near the bridge over the Mississippi river is N. 10° E. and the dip is S. 80° E. $< 10^{\circ}$. Iron mines.

Snow road
north to
Lavant.

Iron mines.

Lavant to
Flower
station.

Clyde forks.

Calabogie
lake.

North of Snow road station toward Lavant, red granite with mica and hornblende schist, continues along the track for a little more than three miles, to a band of white limestone which overlies the schist. The dips of this series, while generally to the south-east, range from S. 20° - 70° E. $< 10^{\circ}$ - 40° , being sometimes suddenly deflected as if through the agency of some intrusive mass. From the point indicated where the limestone first appears on the line of railway, the rocks to Lavant consist for the most part of micaceous and hornblende schist with bands of limestone, the dips as already noted. Occasional masses of red granite show through the schists and limestone. In the northern part of this section the iron mines, called the Wilbur and the Caldwell, are located. The rocks at these mines are largely green chlorite schist, with red granite and dolomitic limestone. The whole are much broken up, apparently by a mass of red granite which cuts the rocks at this place and forms a prominent ridge to the south-east, extending along the east side of the road which leads from the Wilbur mine to the road running east from Lavant station to Poland.

From Lavant station to Flower station the rocks vary somewhat from those just described. There is a greater predominance of mica and garnetiferous schists, and the granite areas are of smaller extent. At the former station the banded and white limestone dips N. 70° E. $< 15^{\circ}$ and extends for nearly a fourth of a mile to a mass of red granite. This continues for nearly a mile and a half or to within half a mile of Folger station, where it is met by rusty hornblende schist which dips S. 40° E. $< 85^{\circ}$ - 90° . North of this station, granitic, hornblende and epidote rocks extend for three-fourths of a mile, with a similar dip $< 70^{\circ}$. Here a band of mica schist, bright and silvery on cleavage, comes to the railway. This rock is sometimes purple-tinted and it extends for three-fourths of a mile, with a dip of S. 20° - 30° E. $< 60^{\circ}$ to a band of limestone with the same dip. From this to Clyde forks the schists are again strongly developed with bands of pinkish and gray dolomite, the dip remaining constant to the south-east, with variations of 20° to 40° degrees. The schists strike N. to N. 30° E. and extend eastward, crossing the road south from Calabogie lake to Darling township. Near Clyde Forks they are cut by masses of red granite. Along the railway thence northward the dolomites and schists continue for about a mile beyond Flower station. On the road south-east from the station toward Joes lake the schists are well exposed till they meet the reddish granite gneiss south of the Clyde river, but from the point indicated north of Flower station to the head of Calabogie lake the rocks are largely hornblende with occasional thin bands of crystalline limestone or dolomite, and the strike is nearly north and south

with a dip to the east. Approaching the lake, the dip swings round to N. 70° E. $< 40^{\circ}$ and thin bands of the limestone come in near the shore. About half a mile south of Rathbun's switch the dip again changes to S. 65° E. and the rocks are broken across by coarse dark diorites. East of this to the crossing of the south bay of Calabogie lake the rocks are drift covered, but an outlier of Black River limestone here comes in with a breadth of nearly a mile, and is well exposed on a road to the south about a mile distant.

Between this bay and Calabogie station the south side of the lake is occupied by a band of crystalline limestone, through which a deep cutting has been made for the railway. This rock is dolomitic and has interbedded layers of hornblende and mica schist in places, the whole being cut by dykes of red granite. The dip of these rocks is S. 30° E. $< 25^{\circ}$. The limestones are sometimes tremolitic, and they are well exposed around the east end of the lake and through Calabogie village. Near the station the strata are nearly flat, while along the river, below the railway bridge, the hornblende rocks are well exposed with a dip of S. 30° E. $< 30^{\circ}$. To the south of this place, large deposits of magnetic iron ore occur which have been worked at intervals for some years. Some of this ore is apparently of excellent quality and apparently quite free from sulphur, but certain portions, judging from the ore in the dumps contain small quantities of pyrites and may be classed as sulphurous.

From Calabogie to Renfrew town the railway presents many outcrops of rock and cuttings are numerous. The schists are often highly micaceous and are associated with bands of dolomite which is frequently beautifully tremolitic, fine specimens being obtainable at several places. A considerable area of blackish gray diorite rock, with granite and syenite occurs between Norway lake and Ashdod station, and extends for nearly a mile south of the former place, where it is in contact with the schists and limestones which are thence exposed almost continuously to Calabogie. Several low anticlinals are seen in this part of the section. East of Ashdod the same granitic rocks continue for about three-fourths of a mile to similar schists and dolomites. The latter frequently present the striped or banded aspect, seen so often in the limestones of the Hastings series, but are frequently cut by masses of the red granite, when they become highly crystalline. These schists and tremolitic dolomites are exposed almost continuously to within a few hundred yards of Opeongo station, the dip being generally S. 60° – 70° E. $< 20^{\circ}$ – 40° , but occasionally there is a reverse dip to the north-west. Masses of pegmatite and red granite are seen

Calabogie to
Renfrew.

at intervals. East of this station to Renfrew Junction, which is one mile west of the town, the rocks are more hornblendic and sometimes gneissic, but have associated bands of mica schist. At the crossing of the creek in the west part of Renfrew near the cheese factory, a band of coarsely crystalline pinkish limestone shows in the bed of the brook, with a dip of N. 10° E. $< 50^{\circ}$, and in the town itself are heavy ledges of bluish-white striped limestone like that of Arnprior, which are extensively quarried for building purposes, and for lime burning, in which the dip is N. 20° E. $< 15^{\circ}$. The black hornblende schist shows along the roads just south of the town, dipping beneath the limestone.

Granite areas. In the townships of Lavant, Darling and part of Bagot the largest development of the schists just described is seen. In the western portion of Lavant these are interrupted by a mass of reddish granite-gneiss which is apparently an extension north-eastward of the large mass seen in Palmerston and North Sherbrooke, and which reappears further to the north-east along the north side of White lake in the southern part of Bagot and MacNab.

Area east of
Kingston and
Pembroke
railway.

East of the Kingston and Pembroke railway the townships are for the most part well opened up by roads, and the examination of the country is correspondingly facilitated and comparatively easy. The southern part of the map-sheet is crossed by the line of the Canadian Pacific railway which traverses the area between Carleton Place and Sharbot lake, and along which rocks of Potsdam and Calciferous age are exposed, from the first named place to a point several miles west of the town of Perth. West of this, however, the rock exposures along and near the line of the railway, are of reddish gneiss and granite. A band of crystalline limestone comes in about one and a half mile east of the west line of the township of Bathurst, and continues for several miles to the westward. It has however but a small development throughout most of its outcrop, and apparently disappears near the east line of the township of Oso. It may represent one of the small bands which has been noted as occurring on the east side of lower Sharbot lake.

Section south
of Maberly.

A section along the road south of Maberly, to the south line of South Sherbrooke, shows, for some miles south of the Canadian Pacific railway, a succession of outcrops of generally reddish granite-gneiss with bands of hornblendic gneiss and granite. A short distance north of the bridge which crosses the Tay river midway between Christie lake and Bob's lake, the limestone band which is seen on the latter, as also on Fagan's lake to the south, is met. This band has in places

a breadth of a mile and extends eastward, apparently crossing Christie lake and continuing in a narrow outcrop into the township of Bathurst. The road south of the Tay eastward, towards Perth, after crossing the limestone area, passes over almost continuous exposures of reddish gneiss, with occasional masses of granite, till it meets the overlap of the Potsdam sandstone. The strike of this gneiss is N. 50°-60° E. and the dip generally north-west.

Throughout the township of Bathurst the red gneiss and granite Bathurst. are the prevailing rocks. An occasional small area of crystalline limestone appears but the rock is essentially a granite-gneiss to the south shore of Bennett lake in the northern part of this township. At this latter place the extension of the limestone belt, noted at Sharbot lake station and along the roads east of that place, comes in and occupies apparently the whole of the area of the lake, which has a length of about five miles, being long and narrow; this band continues, with a widening area, eastward into the township of Lanark. The calcareous Fall brook. rocks are well exposed at Fall brook where they are interstratified with grayish and often rusty gneiss forming apparently the southern limit of the main limestone area of Lanark and Dalhousie townships.

The strike of the limestone and associated gneiss is very uniformly N. 60° E. varying from N. 80° to N. 50° E. for short distances. The prevailing dips over large areas are to the south east, but reverse dips to the north-west are noted at several points. In places the limestone is bluish and slaty, resembling that on Long lake of the Mississippi already described. This slaty feature is well seen a short distance west of Lanark village, but more frequently the rock is highly metamorphic and contains an abundance of quartz in strings and irregular bunches, which on weathered surfaces gives the mass a very rough appearance.

In the north portion of Bathurst and in the southern part of Dal- Dalhousie. housie which adjoins it on the north, the belt of limestone has a breadth of several miles extending to the shores of Dalhousie lake. In the south-west corner of the last named township it is associated with hornblende rocks which are well exposed to the west of the road leading from Playfair to McDonald's corners. The north-west limit of this limestone area is seen near the south-west angle of Dalhousie lake, where it is in contact with the mass of red granite of South Sherbrooke, but along the road from McDonald's corner almost to Elphin, the calcareous beds are well exposed. They are well banded or striped and have a dip of S. 40° E. On the road from this corner to the foot of Dalhousie lake they are also well seen, and they occupy the lower end

of the lake, on the north side, for about a mile above the outlet. From the foot of the lake along the straight road leading to Watsons corner the limestone is almost constantly exposed but the dip is here reversed to N. 20°-30° W. < 30°, showing the presence of an anticlinal in this direction. About midway between the foot of the lake and Watsons corner it is invaded by a mass of red granite, but this does not apparently affect the general run of the strata. These limestones present the striped aspect already referred to.

Dalhousie
lake to
Poland.

On the road north from the foot of Dalhousie lake towards Poland the calcareous strata extend for about a mile to a mass of red granite, which is thence exposed along this road to Patterson lake, and further on becomes associated with masses of black or sometimes greenish hornblende rocks which extend thence, with but slight interruption, to the northern limit of the township. On the road north from Watsons corner between ranges II. and III., the striped or banded limestone extends for about a mile also, when it is met by granite ridges, and becomes in places interstratified with beds of grayish and sometimes rusty gneiss. Along this road about three miles distant from the corner there is a deposit of pyrrhotite with diorite in the rusty gneiss which has been slightly opened up, and the mineral found to contain a small percentage of nickel. There are alternations of limestone and gneiss with granites for about three miles north of Watsons corner, when the calcareous portion of the series apparently disappears in this direction. The last outcrops of the limestones are noted about half a mile north of the church at the cross roads on lot 16. Thence north to the limit of the township the rocks are red granites with great masses of black hornblende diorites in which there is generally no trace of foliation. These hornblende rocks occupy a large portion of the northern half of the township of Dalhousie. In places a schistose structure is visible, but for the most part the rock is massive. They extend into the southern portion of the township of Lavant adjacent on the north, where they are also mixed up with masses of reddish granite, forming a rough country of but small agricultural value. Detached areas of dolomite of limited extent are occasionally seen which weather very brown and are ochreous, assuming sometimes the character of a dolomite schist, and the massive rocks of the district generally present the features of intrusive rocks in the schists and limestone.

Poland west
to Lavant
station.

Poland village is in the northern part of Dalhousie township, and from this point roads extend west to Lavant station on the Kingston and Pembroke railway, and north through Lavant township. To the

south a road extends also to the foot of Dalhousie lake connecting with other roads which traverse the north-west portion of the township. On the road west to Lavant station the rocks for some miles, or almost to Robertson lake, which is in the south-west corner of Lavant, are mostly reddish and granitic or dark coloured and hornblende. A band of crystalline limestone crosses this road at a stream on the township line where there is a mill, about midway between the village and Robertson lake. The limestone does not extend far to the east as it is not seen on another road leading north from Poland, being apparently cut off by a mass of the greenish-black hornblende rock which has an extensive development in this direction. To the south-west, however, it may be continuous with a band of limestone which appears on the Lavant mill road south of Robertson lake, and which may be the north-east extension of one of the bands seen to the east of Snow road station. A second band appears on the road to Lavant station a short distance east of the lake at Lavant post office. This band extends past the south end of the lake, beyond which point it has not been traced.

The shores of Robertson lake on the west side are composed entirely of ordinary reddish granite, which in places shows foliation, but is generally massive. This appears to be the eastward extension of the great area of granite-gneiss already referred to as occurring around the shores of Gull and Croche lakes and which occupies the northern portion of the township of North Sherbrooke. The granite extends west of the lake to the forks of the road leading to the Wilbur iron mine, along which it is well seen to the eastward in a prominent ridge, but beyond this point the schists and associated limestone come in and extend to the Kingston and Pembroke railway. The schists in this part of the section are often highly micaceous.

On the Lavant mill-road from Robertson lake south, to the head of Dalhousie lake and on a branch road leading thence to Snow road station, almost continuous exposures of black hornblende rocks, with masses of red granite, are seen. About midway a band of limestone comes in with a breadth of several hundred yards which may be the extension westward of the band referred to on the road west from Poland, though its connection has not been traced. Along the north side of the Mississippi river, east of the Snow road crossing, limestones are exposed but these are much broken up by masses of granite and diorite and their distribution is very irregular. The northern portion of North Sherbrooke may be said to be largely occupied by masses of granite and hornblende rocks in which small areas of limestone are

sometimes seen, but these are usually highly altered and have an abundance of disseminated quartz.

Area south
of Poland.

On the roads traversing the central portion of Dalhousie, south of Poland, the same black hornblende rocks, associated with granites, are predominant. Several small bands of limestone were noted in this area but their distribution is evidently local since they cannot be traced to any considerable distance in either direction. The southern part of this area, in the vicinity of Patterson lake, and to the north of it is apparently occupied largely by the red granites to the contact with the limestone area already noted as extending along the road from Dalhousie lake to Watsons corners.

Area north
of Poland.

North of Poland village, the roads thence into Lavant township as far as Clyde forks, and thence east to the Darling road, show a considerable development of hornblende rocks. In places these consist of massive diorites with areas of schists, and occasionally there are masses of red granite. Bands of dolomite, sometimes very ochreous on weathered surfaces, occur, and sometimes these are filled with strings and bunches of white quartz; but the eastern half of this township is largely occupied by the rocks of the hornblende series. Indications of ores of several kinds are found at different points, including iron, copper, etc., but much of the district is unsettled and has never been thoroughly prospected for economic minerals.

Calabogie to
Brightside
post-office.

A good section is afforded by the road which traverses the townships of Bagot and Darling from the east end of Calabogie lake to Brightside post-office, formerly La Rocques corner. Near the lake the rocks along the road are limestones with schists of several kinds, and occasional masses of diorite on either side, in which are located several of the iron mines of the Calabogie area. These ores have been mined at intervals for some years. A mass of red granite comes in near the cross road about one and a half mile south of the bridge over the Madawaska river and has a breadth of several hundred yards. This is followed southward by black hornblende schists with diorites for a couple of miles to a small lake on the west side of the road. Here a band of dolomite, containing an abundance of quartz in strings and bunches, crosses the road and extends west for a mile or more into the unsettled country. This band has a breadth of about half a mile, and is again succeeded by similar hornblende schists and diorites as before with a breadth of a mile, to a somewhat extensive area of the quartz-bearing dolomites which comes from the vicinity of White lake on the east. This dolomite area is exposed along the roads for nearly three miles and extends across into Darling township. The band apparently

dies out a short distance west of this road, and thence to White post-office, the rocks are a succession of these quartz-bearing limestones with bands of hornblende rock which sometimes are true schists. Occasional masses of red granite are seen, but the rocks as a whole are distinctly hornblendic. The strike of these is uniformly to the north-east, the dip not always easily determined. South of White post-office diorites and granites extend for about three miles, with one or two narrow bands of dolomite, but at this point a somewhat broad area of limestone comes in which extends thence nearly to Brightside, or to the road north of that point which leads across to Tatlock. This limestone is the usual striped variety with bands of grayish rusty gneiss and has a south-east dip. Near Brightside it meets an area of granite which is well exposed along a road which follows the township line in the direction of Clayton. The limestone band just indicated continues north-east to Tatlock where it crosses a road leading north, with a breadth of about two miles, and is thence continuous into MacNab as part of the great calcareous band of that township. North of Tatlock it is separated from the large area of White lake by a belt of green diorite or chloritic rocks, which extends to near the end of the long south-east bay of that lake in the township of Darling.

The north-east part of this township is intersected by White lake which extends south-west from White lake post-office in the southern part of MacNab. The south-east side of this lake is marked by several deep bays and large exposures of the striped limestone are everywhere visible. This is terminated westerly by the great mass of the hornblende rocks described as occurring on the road south from Calabogie. The north side of the lake is occupied by a heavy mass of generally reddish granite, which occupies the south-east corner of Bagot. East and north of this lake the limestone spreads out and continues into the townships of Pakenham and MacNab till it is overlain by the Black River limestone of the Ottawa basin or by the Calcareous and Chazy formations of Arnprior and Sand Point. The strike of the crystalline limestones at White lake post-office is N. 60°-70° E. and the dip is north-west < 60°-70°.

The roads from the foot of White lake at the post-office continue north-east to Arnprior, and north-west to Burnstown on the Madawaska river. Along the latter the limestones are exposed almost continuously to the cross roads half a mile south of the river, where the dip becomes reversed to S. 15° E. < 80°. Here, thin bands of gneiss and schist are associated, and the limestone area practically disappears when the river is crossed at Burnstown, giving place to

White post-office.

White lake.

White lake to Arnprior.

black hornblende rocks and schists with areas of reddish granite. On the continuation of this road to Renfrew the limestone does not appear or but slightly, till within a couple of miles of the latter place, where a band several hundred yards in width crosses the road in a north-east course, and continues on its strike to the line of the Canada Atlantic railway. The rocks along this road to Renfrew dip S. 20°-30° E. the dips ranging from < 30°-90°.

Area south
of Renfrew.

From this road another turns off west about midway between Bushington and Renfrew, and traverses the south-east corner of Bagot, crossing for the most part an area of red granite, which is often coarse and without foliation. This road extends across to one which connects the villages of Springtown and Bushington, along the north side of the Madawaska river, and no limestone was observed in this direction.

On the road north-east from the foot of White lake to Arnprior the same area of crystalline limestone is seen for a distance of about one mile and a half. The road descends in this distance from the high ground of land at the lake to the great flat area south of Arnprior which is occupied in part by Black River limestone, but here the rocks are mostly concealed by a great covering of clays. All these limestones are of the striped variety and they again appear in the town of Arnprior, from beneath the mantle of Calciferous limestone, where they are extensively quarried for lime-burning and for building.

Blythfield
and Canonto.

A somewhat important area of this limestone is also found in the north-west part of the township of Blythfield, to the west of Calabogie lake, where it has a breadth in places of nearly two miles. From the west end of this lake it can be traced in a curving outline, south-west across the Madawaska river into North Canonto, and it is probably connected there with the outcrops which have been described as occurring on the shores of Mud lake, in the Madawaska river section, where however this rock is interstratified with heavy bands of gneiss. North-east from Calabogie lake it extends across the corner of Bagot into Admaston, where it is associated with gneiss and hornblende rocks, and thence, continuing north-east, reaches the Ottawa river below the village of Portage du Fort, where it is much disturbed and sometimes entirely cut off by masses of anorthosite and of red granite on the north side of that river. The limestone along this part of the Ottawa are associated with bands of rusty greyish and black gneiss which are identical with those seen with the limestones of the Grenville district, the rocks of the two sides of the river being identical in many respects and the strata continuous. While the strike of these rocks is to the north-east they present minor variations

Anorthosite
of Portage
du Fort.

and are also thrown into several folds as though the strata were displaced by the agency of intrusive masses of granite and anorthosite, the latter rock appearing in a large mass, several square miles in extent, to the south of the village of Portage du Fort, in the northern part of the township of Horton. This area of limestone is separated from that of the White lake basin by a great mass of granite-gneiss in MacNab township which appears along the line of the Canada Atlantic railway between Renfrew and New Glasgow and for some miles on either side, and which occupies the country to the foot of the Chazy and Black River ridge south of Sand Point, which is on the shore of the Ottawa about five miles west of Arnprior.

The synclinal character of the large limestone basin of White lake Syncline and the Madawaska river is seen by the reverse dips of the strata at Stewartville, which is north of the river, where they are well exposed to the south. The strike is here deflected to the east and even a little of east as if by the agency of the granite mass already referred to along the Canada Atlantic railway east of Renfrew. In this case the structure of this basin resembles that already noted as prevailing in the areas to the south and west as also at points along the north side of the Ottawa; and it may be generally stated that this synclinal feature is general throughout the greater portion of the area under consideration.

In the township of Ramsay the broad belt of crystalline limestone Ramsay which occupies the greater part of Lanark adjacent on the west, has its northern margin near the village of Clayton in the north-west angle of the township. To the west of this in the north-east part of Lanark the strike of the limestone suddenly changes from its usual course of N. 60° E., to S. 50° E. with a south-east dip as if deflected against the great mass of red granite which occupies the north-west part of the township of Pakenham. The contact of the limestone and gneiss follows closely the road east from Clayton towards the Mississippi river and maintains a south-east dip for some distance; but to the south of this a reverse dip to the north-west is seen at several points, while several minor folds occur in the centre of the basin itself.

The distribution of these several formations of gneiss, limestone and granite can best be seen by reference to the map. It would appear from the examination of these rocks, over widely separated areas, that there is a marked resemblance at many points, and that in fact most, at least of the limestones and associated schists, with gneiss, are repeated from point to point, forming basins of approximately the same horizon. In all cases the limestones present practically the same striped or

General structure of the limestones and schists.

banded aspect so common to these rocks in the Hastings series, except where this feature has disappeared through a greater metamorphism of the strata, when they become less definitely marked and assume the characteristics of the limestones of the typical Grenville district. This more highly crystalline condition appears to be more strongly marked on the whole, as the Ottawa river is approached, and, while the different strata of limestone, rusty gneiss, and sometimes the schists, can be traced directly across the Ottawa, the striped character of the beds is rarely there noticeable. The peculiar aspect of the limestones containing quartz, so frequent in these rocks to the south of the Madawaska river is rarely seen north of the Ottawa and these indications of metamorphism, as also their tremolitic character, would therefore appear to be due rather to local causes than to wide areas of regional alteration.

Ridge south
of the Ottawa.

A somewhat prominent ridge of these old crystalline rocks, separated from the main mass already described by a great intermediate basin of Paleozoic strata, is seen to the south of the Ottawa river east of Arnprior, in the townships of Fitzroy, Torbolton, Huntley, March and Nepean. It does not appear on the south shore of the Ottawa, since it is concealed in that direction by the overlying beds of the Potsdam, Calciferous and Chazy formations, while the overlying beds on the south, in the valley of the Carp river, are mostly of Black River and Trenton age.

The rocks of this old ridge are largely reddish gneiss with granite, some of the latter being apparently of quite recent date, since in the township of Nepean they are seen to cut or alter the overlying beds of the Potsdam sandstone at one point at least. In the western portion of the ridge near Fitzroy Harbour, there is a large development of crystalline limestone which presents similar features to the limestones already described in the areas further to the west, in the presence of scales of mica and graphite as also of chondrodite, and of rather indistinct lines of banding. They are in this vicinity penetrated or invaded by masses of granite, sometimes in the form of dykes of large size, and this feature can be well seen at the Chats falls, where a large mass of this granite crosses the river, cutting the limestone and forming a huge barrier over which the water of the Ottawa river falls. To the north of the Chats falls, masses of green hornblende and schist rocks are found which contain quartz veins and masses, in which explorations for gold have been carried on. Detached areas of the limestone are seen at various points in the ridge of these crystalline rocks, but cannot be traced continuously to any considerable distance. They appear to be cut off in places entirely by granite masses. North of Carp village

Chats falls.

Gold.

on the road to South March, there is a considerable development of highly quartzose dolomite limestone, which is like much of that seen in Darling township. The eastern portion of this ridge is more granitic, and large dykes of pegmatite are visible. Well defined garnetiferous gneiss is, however, seen at some points and good exposures occur 150 yards west of South March station, where the strike is well defined with an east and west course and a south dip $< 75^\circ$. Masses of dark, often coarse, diorite are seen in the vicinity in which irregular deposits of dark mica are common, but the mineral here is of but small economic importance. Similar black micas are seen to the north of the village of Carp and have been worked to some extent. Near South March station also several narrow bands of the limestone are found which are cut by pegmatite dykes, and these contain at one point deposits of graphite in small quantity. Portions of the pegmatite are highly felspathic and might be worked to some extent for economic purposes. The eastern extremity of this ridge in March and Nepean townships is overlain by sandstones of the Potsdam formation, the transition between this and the Calciferous limestone being well seen at a number of places.

Carp and
South March.

ECONOMIC GEOLOGY.

Very full details of the principal economic minerals found in the area included in this report have already been given in the several reports by Mr. H. G. Vennor, extending from 1871 to 1876. Some additions must however be made to this list as there described, owing to more recent investigations and developments.

Economic
minerals.

The chief minerals of economic importance include iron, gold and silver, galena, nickel, mica, apatite, graphite, corundum and feldspar, and among other important economic products may be enumerated building stones, bricks and tiles, dolomites, shell-marl, lime and peat.

The most largely distributed of these in this area are the deposits of iron which are found at a number of widely separated points. Many of these are found in close proximity to the line of the Kingston and Pembroke railway, which connects the town of Renfrew with the city of Kingston. These deposits have recently been very carefully studied by Mr. Ingall, * of this department, and his report on the subject contains full descriptions of all the important mines in the district. It will be necessary therefore in this place merely to refer to the principal localities where these ores are found.

Iron mines.

* Annual Report, Geol. Surv. Can., Vol. XII, (N.S.), part I.

Among these may be mentioned the Bygrove and Fournier mines, the former on lot 3, range I, South Sherbrooke, the latter on lot 14, of the same range. These have also been described in Vennor's report on the area for 1874-75, pages 122-123; and the Christys lake mines on lots 18, 19 and 20, range III, and lots 17 and 18, range II, of the same township, also referred to in the same report on page 120, and in that for 1872-73, on page 174.

In the township of Bathurst, the Foley mine is situated on lots 10, and 11, range V. In Dalhousie township, the Dalhousie or Playfair mine is on the east half of lot 1, range IV, and is described also in Vennor's report for 1872-73, page 176.

In South Sherbrooke township also, near the shore of Silver lake, several openings have been made on lots 14, 15 and 16, range IV.

Along the line of the Kingston and Pembroke railway, the Roberts-ville mine is located on lot 3, range IX, of Palmerston, township the Wilbur mine on lot 3, range XI, of Lavant township, and the Caldwell and Radenhurst mine on lot 22, ranges III and IV, near Flower station.

About Calabogie lake several mines have also been opened, and worked quite extensively, on lot 16, range X, township of Bagot, and on lot 16, range VIII, and several practically undeveloped areas are found between the Madawaska river and Norway lake. To the south-west of the White lake is the Yuill mine on lot 25, range V, Darling township, and on the south side of the lake are Bell's mine on lots 23 and 27, range XI. The Robertson mine is on lot 1, range I, also of Bagot.

Character
of the ore.

The ore from most of these mines is magnetite. In places this contains pyrites in small quantity and the ore is in consequence somewhat sulphurous, but much of the output is comparatively free from this ingredient and the mineral is correspondingly valuable. In the Dalhousie mine the ore is hæmatite and this also is found at Bell's mines on White lake, where both the red and black iron ores occur. The value and extent of this last named deposit has apparently never been thoroughly tested.

Near the village of Dacre in the north part of the township of Brougham, a deposit of magnetite is seen which has recently been quite extensively worked by the Canada Furnace Co. It is about half a mile south of the cross-road at that village. In the town of Arnprior a deposit of hæmatite was worked some years ago. It apparently occurs along a line of fault between the crystalline lime-

stone and the Calciferous dolomite. The deposit at this place is said to be nearly exhausted, but the mineral occurs at several points along the line of a fault in a south-west direction from the old shaft.

In the township of Grattan, on lot 16, range IX, and on lot 17, range X, a large deposit of magnetite is now being opened by the Canada Iron Furnace Co., of Montreal. The location is about four miles south of Caldwell station on the Canada Atlantic railway, and appears to be quite extensive, several thousand tons having been already extracted.

Generally speaking, these ores occur in connection with crystalline limestone, though sometimes in granite or diorite masses. Eruptive rocks are frequently found in close proximity to the ore bodies, which are often pockety in character, and in some places they are in connection with the eruptive rocks entirely.

Mode of occurrence.

The Dalhousie or Playfair mine appears to occur altogether in the crystalline limestone. A full description of this deposit is given in Mr. Ingall's report, 1901, page 70 I.

GOLD.

The known deposits of gold in this area are few. The mineral has, however, been found at several places, and mining has been carried on quite extensively for some years, notably in the township of Clarendon, Frontenac county, between the villages of Plevna and the Mississippi river at Ardoch.

Two mines are here located, viz., the Webber, on lot 28, range VIII, Clarendon, and the Boerth mine on lot 28, range VII. At the former place little actual mining work has been done, though a stamp mill was erected on the property some years ago. The ore is found in small irregular strings of quartz associated with reddish gneiss and granite which cuts the crystalline limestone of the Long Lake area on the Mississippi river. At the principal opening a dyke of diabase cuts the rock, and the quartz veins appear to be connected with this intrusion. No reliable information is available as to the actual results obtained from the operations at this place, and only a limited amount of development work has been done, probably owing to lack of capital on the part of the owners. The quartz, however, carries gold in small quantity.

The Boerth mine was started several years ago on the lot adjoining the Webber property on the east. It is near the road leading from Ardoch to Plevna. Here the veins are evidently larger and apparently

carry a larger percentage of gold. A stamp mill and concentrating plant were erected and a large amount of money was expended in the attempt to extract the gold from the ore, though but scanty information is available as to the actual results obtained. Mr. Walter Wells, the provincial assayer of Belleville, states that the percentage of gold in portions of the quartz is fairly high, but that the ore is very refractory.

Denbigh.

In the southern part of the township of Denbigh, gold has been reported from several points. No definite exploration has, however, as yet been carried on in so far as can be learned, though some blasting work has been done. The rocks in the area are mostly granite and gneiss with some diorite with which the small quartz veins are associated. Near Eagle hill, also at Fergusons corner, a small opening was noticed in a quartz vein which was said to carry gold, but none was visible in the rock and no work has been done here for some years. The similarity of the rocks in this belt to those which occur in the Madoc and Marmora area is easily recognized, and the mines referred to are apparently in the north-east extension of that belt.

Griffith.

Further north also in the township of Griffith, gold has been reported as occurring in quartz veins situated to the east of the road from Griffith bridge to Dacre, but no satisfactory information as to the nature of the deposit has yet been received. In the southern part of the township of Lavant, a small percentage of gold was also found in an assay of ore from lot 12, range IV, in connection with copper. The ore is pyritous, and occurs in a band of limestone near eruptive rocks. A shaft was sunk to a depth of 70 feet but no details as to results are available.

Lavant.

An assay of quartz, by Dr. Hoffmann, taken from the west half lot 10, R. VI, Lavant, Lanark Co., yielded 0.195 oz. of gold to the ton, and a white quartz carrying small quantities of copper and iron pyrites and some galena from the N.E. portion of lot 12, range II, South Sherbrooke was found, (Ont. Bureau of Mines, 1901, p. 204) to contain 3.500 oz. of gold to the ton, and 0.428 silver.

It seems probable therefore that gold will be found at a number of points in this district, under conditions somewhat similar to those which prevail in the Marmora area. The presence of masses of intrusive granite and diorite through the associated hornblende rocks and crystalline schists, which have a wide distribution, is supposed to be favourable to its occurrence, but the results so far have not been commercially successful. The ore is largely pyritous rather

than free-milling, so that expensive methods of treatment may be necessary for its extraction.

SILVER AND GALENA.

Deposits of these minerals occur at several places in the map area, notably in the township of Barrie, and principally in connection with the belt of limestone and dark hornblende rocks which extends from the west end of Long lake, on the Mississippi river, along the road from Myers Cave post-office to Ardoch. This road keeps along the narrow strip beneath this lake and lake Missasagagon to the north. Several openings have been made on the upper or west end of Long lake at the portage to Whitefish lake, which is a short distance south of Perry, but the ore indications at this place are small. The rocks consist largely of crystalline limestones which have been altered from the bluish slaty limestone of the area, apparently by the agency of the granite masses in the vicinity. This place is known usually as Myers cave. Silver and galena.

Along the road to Ardoch, however, on lot 12, range VIII, Barrie, a shaft was sunk some years ago on a band of silver-bearing galena, portions of which on assay gave a fairly high percentage of silver. Work was discontinued at this place owing to litigation as to ownership of property, and at the time of visit the shaft could not be examined. The country rock is a crystalline limestone with bands of black hornblendic slaty or schistose gneiss. This formation continues eastward across the township, and the gold mines north of Ardoch are practically on its extension. Several assays of the ore from this place were made in the laboratory of the Geological Survey, the percentage of silver, in one case from a sample from lot 12 of rather coarsely crystalline galena, being 137.883 ounces to the ton of 2,000 pounds and a trace of gold, while a sample from lot 9 of the same range gave 119.583 ounces of silver to the ton but no gold. Barrie.

A number of assays have been made from time to time by Dr. Hoffmann from other places in the area of the map-sheet, and for the sake of convenient reference these have been collected from his reports and are here inserted. Assays.

In the township of Darling, Lanark county, on lot 19, range III, an assay of quartz from a vein gave neither gold nor silver. One from lot 25, range V, same township, gave a trace of gold but no silver. Another from the west half of lot 22, range IV, gave 0.111 of an ounce of gold and 5.176 ounces of silver. Darling.

Lavant.

In the township of Lavant, on lot 10, range VI, a rusty pyritous gneiss yielded at the rate of .175 ounces of gold and no silver. Another assay of a sample from the east half of lot 12, range IV, from a pyritous dolomite, gave a trace of gold, and one from the east half of lot 12, range II, South Sherbrooke, from a quartz vein containing pyrites and galena, gave gold at the rate of 3.50 ounces and silver 4.08 ounces to the ton of 2,000 pounds.

Clarendon.

In Clarendon township, Frontenac county, a sample of quartz from lot 28, range VIII, gave 2.098 ounces of silver to the ton but no gold; one from lot 26, same range, neither gold nor silver; samples from lot 35, same range, neither gold nor silver, and like results from samples from lot 38, range X. A sample of quartz from lot 26, range IX, of the same township, with galena gave silver at the rate of 59.662 ounces, but no gold. Samples from lot 34, south-west concession of Frontenac road, from quartz containing pyrites and pyrrhotite, as also similar samples from lot 32, range XI, and from lot 42, north-east concession, gave neither gold nor silver.

From the above assays of specimens from different places in the township just mentioned, there would appear to be an area of considerable extent in which a well defined mineral bearing zone exists and in certain portions of which the prospects for profitable mining may be reasonably expected. The greater part of the ore is, however, associated with pyrites in so far as the gold is concerned, so that the extraction is, as a rule, somewhat difficult and probably expensive.

Carleton Place.

In the Geology of Canada, 1863, reference is made to a mine in the township of Ramsay, a short distance west of Carleton Place, which was opened on a vein of galena, cutting a grayish dolomite of Calciferous age. The galena occurs with iron and copper pyrites associated with blende in a gangue of calc-spar. Work was carried on for some time at this place about forty years ago, and a smelting furnace was erected. A considerable quantity of the ore was raised, but the smelting was found to be unprofitable, and the vein appeared to terminate when the underlying Potsdam sandstone was reached. Operations were abandoned many years ago and the works have fallen into decay.

Fitzroy.

Galena also occurs in the township of Fitzroy, near the road leading from Galetta to Fitzroy harbour. A lead-bearing vein was opened on the 20th lot of range VIII, having a width of six inches, cutting crystalline limestone, but it has apparently never been worked. On Laflamme's island, below the head of the Chats rapids, on lot 26, range VI, there is also a deposit of galena, known as Robertson's mine, which

was opened some years ago and worked to some extent. The ore is disseminated in a calcite vein in crystalline limestone, near a large dyke of red granite, and carries but little silver. The shafts have long been filled with water, and nothing has been done at this place for a number of years.

GRAPHITE.

Graphite is found in connection with the crystalline rocks at a number of places in workable quantity. Of these the most extensive deposit is that in the township of Brougham, lot 1, range III, on the south-west side of Whitefish lake. The country is a crystalline limestone which is cut by dykes of red granite. The graphite is in the form of a large bed or bedded vein, ranging from six to over ten feet in width at the surface, and following the strike of the gneiss and limestone which has a course of N. 45 E. with a dip to the south-east of 60 degrees. The mineral is underlaid by a hard pegmatite dyke and the vein increases in width as a greater depth is reached. In places the mineral is found on both sides of the dyke, and the mass of ore extends out under the water of the lake. This dyke also holds scales of graphite, which is rarely disseminated throughout the gneiss of the vicinity. The dyke is evidently more recent than the gneiss and limestone and has altered these along the line of contact. Iron pyrites occurs also in the gneiss along the contact with the granite. This ore has been worked for some years and extensive works have been recently erected for preparing the ore for market, power being obtained from the Madawaska river which is in close proximity to the mine. The ore is largely of the amorphous variety but a flake structure is seen in portions of the bed. The output is hauled to the Kingston and Pembroke railway at Calabogie lake. For details see "Bulletin on Graphite." A similar deposit is seen in the township of Darling, near Tatlock post-office, but does not appear to be so promising. It has as yet not been opened.

Graphite.
Black Donald
mine.

Near Olivers ferry, on the Rideau canal, on lot 21, range VI, North Olivers ferry, Elmsley township, a deposit of flake graphite occurs in a gray gneiss and limestone. The location is about three-fourths of a mile from the shore of the river. The property was worked to some extent a number of years ago and a plant for the separation of the mineral was erected on the bank of the canal at the Ferry. Recently work has been resumed with a good prospect of success, as the mineral forms an extensive deposit and is convenient for shipment.

High falls,
Madawaska.

At a number of points throughout the district, graphite occurs as disseminated scales in the crystalline limestone, but such occurrences are of no economic importance in so far as yet recognized. Above the High falls on the Madawaska river, on lots 13 and 14, range IV, Blythfield township, on property owned by Mr. James Bailey, an opening has been made in a gray gneiss. The mineral appears to be in fair quantity, though but little work has been done towards its development. Some work has also been done on a deposit of this mineral on Con. II, South Canonto, the extent of which is as yet unknown.

MICA.

Mica.

The occurrence of this mineral in the pyroxenic rocks near the lower portion of Rideau lake, in the township of North Burgess, has been known for many years. Extensive mining for apatite was carried on in this district over thirty years ago, the details of the different mines being given at some length in the reports by Mr. H. G. Vennor for the years 1873-74 in connection with his notes on the occurrence of apatite in this district. Mica almost invariably accompanies the apatite in all the mines of the area, but at that date was regarded simply as a waste product. The same association of the two minerals is recognized at many of the mining locations north of the Ottawa, and here the proceedings are reversed, the mines now being worked for mica only, while the apatite is saved as a by-product.

North and
South Burgess

Probably the first reference to the mica of this district is found in the *Geology of Canada*, 1863, pages 494 and 795. It is also referred to in the report by Mr. Gordon Broome, in the volume for 1870-71, page 321. Mica has been mined quite extensively in the township of South Burgess, on the south side of Rideau lake, some of the shafts reaching a depth of over 100 feet, from which a large amount of excellent mica was obtained. Several of the mines in North Burgess have also been operated during the last ten years, but no information as to output is to hand. The conditions under which the mineral occurs at all these places, are identical with those found in the areas north of the Ottawa river and described in the report on the Grenville sheet, Part J, Vol. XII, 1899.

Clarendon.

In Clarendon township, lot 24, range II, a deposit of white mica has been worked irregularly for some years. The mineral, however, is affected by inclusions of iron which render much of the output useless for electrical purposes. In the vicinity of South March station, on the Canada Atlantic railway, and also near the village of Carp, further

west, there are several irregular deposits of a very dark variety which have been opened up, but as yet not worked largely.

A number of mica mines occur in the townships of North and South Burgess, some of which have been extensively worked for a number of years. Among these in North Burgess may be mentioned the Hanlan mine on lot 2, range VI; the Martha mine, on lot 13, same range; the Baby mine, lot 2, range V, on the south side of Long lake; the Byrnes mine on lot 11 and east half of lot 12, range VII; the Watts and Noble mine, on lot 4, range IV; the Pike Lake mine on lots 16 and 17, range IX, near Stanleyville, the product being largely muscovite; the Blackhall mine on lot 10, range V; the McNally mine on lot 21, range V; the McLaren mine on lot 4, range VIII; the McMarten mine on lot 1, range VI, and the Munslow mine on lot 13, range VI. In South Burgess, the Canton mine on lot 1, range IV, and the Downey mine on lot 7, range I. The Bliss mine is in South Burgess, about 12 miles south-east from Perth by road; the Blair mine on lot 3, range IX, Bathurst, and the Gibson mine on lot 25, range IX, North Elmsley. On some of these properties a large amount of work has been done and much mica of good quality extracted. The area in North Burgess shows a large development of pyroxene rocks in which both apatite and mica occur and the district has been known as a mining centre for over thirty years. Most of these mines were examined in 1901, and the conditions seen were similar to those which prevail in the mica district north of the Ottawa. Work is still being carried on at several of these locations. For further details see "Bulletin on Mica."

Mines of
Rideau area.

APATITE.

The distribution of the principal apatite deposits in North Burgess, where this mineral is most abundant, is given in the reports of Mr. Vennor already alluded to. Work was carried on in this area for a number of years and there is a large district north of the Rideau lakes where the mineral occurs in sufficient quantity to be of economic importance. Unfortunately the decline in the price of apatite, by which the mines of the Ottawa district were obliged to suspend operations some years ago, has affected all the mines of the area under discussion, and the only production now is merely as a by-product from the mining of mica.

Apatite.

In the township of South Sherbrooke, lot 11, range VII, crystal good size are obtained from calcite veins in pyroxene, but the locality

has never been a producer, and as a rule it is found that the occurrence of apatite crystals in this mineral only rarely reaches the economic stage of production.

CORUNDUM.

Corundum.

Though the principal deposits of this mineral are found in the area comprised in map-sheet, No. 118, adjoining the present one on the west, the corundum bearing belt of rocks has been traced eastward from this area, which abuts on the Madawaska river near the foot of Kaministiquia lake and crosses the river at the Palmer rapids a few miles below, into the township of Lyndoch and thence into Sebastopol and Brudenell in the direction of Clear lake. The belt also extends into the adjacent township of South Algoma which lies just north of the limit of the map sheet. The mineral itself has not, however, been found as yet in economic quantity east of the Madawaska river.

In the southern portion of the area similar rocks carrying corundum have been recognized in the southern part of the township of South Sherbrooke, and also in North Crosby and North Burgess, but the explorations so far carried out in this direction have not so far revealed its presence in sufficient quantity to warrant large expenditure in the present condition of the market for the material.

COPPER.

Copper.

References to the occurrence of copper at various points in the area under discussion are found in several of Vennor's reports, more especially in that for 1874-75. From the descriptions there given it would appear that a somewhat broad belt of copper-bearing rocks is found extending from the south-east corner of Palmerston township through Lavant and into Darling, in which copper ore is found in a number of places. These are well described on pages 161-162 of the report referred to and need not be repeated here.

Considerable development work has also been done at the Helena mine on lots 19-20, range VI, and lot 20, range VII, Barrie. The ores are copper and gold in a quartz vein, cutting crystalline limestone, but operations have been suspended since 1901.

DOLOMITE.

Dolomite.

Quite recently there has been a considerable demand for this mineral in connection with the manufacture of chemical wood-pulp. Magnesian limestones suitable for this purpose occur at a number of places

some of which could be readily utilized. Among these may be mentioned the following:—

On lot 22, range VIII, Lanark, a limestone with 42·10 per cent of carb. of magnesia. In Dalhousie township, lot not named, a similar rock with 42·63 per cent, and on lot 27, range IX, Barrie, a limestone with the same proportion of magnesia as the last-mentioned.

On lot 10, range IV, of Aldfield, in the province of Quebec, but not in the limit of the present map-sheet, a dolomite is found with 46·01 per cent of magnesia.

In the township of Ross, lot 19, range VI, a large area of very pure dolomite, giving over 40 per cent of carbonate of magnesia occurs. On lot 9, range XIV, township of MacNab, a calciferous dolomite gives carb. of lime 53·00 per cent and carb. of magnesia 43·88 per cent, see Report 1876-77, p. 486. This is near the Ottawa, about two miles west of Arnprior.

BUILDING STONE.

The limestones of Black River age, as also of the other formations to the top of the Potsdam sandstone frequently yield stone well adapted for purposes of construction. Among the sandstones of Potsdam age the large quarries in the western part of the township of Nepean have already furnished a large amount of the material used in the Parliament buildings at Ottawa, while certain portions of this rock are sufficiently free from iron to be employed for glass making. Unlimited quantities of this rock are available in the areas to the west of Ottawa in the western part of the great Ottawa River basin.

The Calciferous dolomite has also been somewhat extensively quarried for building stone at a number of points. Large quarries of this rock of a brownish colour are found near Carleton Place, on lot 20, range IX, Ramsay. A fine white sandstone also occurs at this place. There is also a quarry on the south side of Otty lake near Olivers ferry, the stone being used for the Tay canal.

In the Chazy formation, in addition to the limestones available for building stone and lime burning, certain bands occur which have been somewhat largely used for the manufacture of cement, as in the case of the Wright quarries near Hintonburg. This band lies near the middle of the formation or at the base of the upper or calcareous division.

The Trenton limestones are too well known to require further description. Good bands are found wherever the formation occurs.

Among the crystalline limestones, those of the Hastings series furnish large quantities of fine material both for lime burning and for construction purposes. Among the largest quarries may be mentioned those of Renfrew and Arnprior, but there are large areas of good material at a number of places, only the distance from convenient shipping points being against their present development.

Granites. Many of the granites and granite-gneisses would also furnish an excellent stone for building purposes, but except for local use and on a small scale, these have not yet been utilized.

Felspar. Felspar, which forms a large part of many of the pegmatite dykes and masses so numerous in the crystalline rocks is of value for the manufacture of pottery and for some of the grades of porcelain. The cost of transport is, however, in most cases too great to render it at present economically available, unless where the material occurs in close proximity to lines of railway. The percentage of pyrite in some of this rock seriously affects its value.

Brick clays. Brick clays are widely distributed throughout a large part of the area, especially in the Ottawa and Rideau basins. They are quite extensively used for the manufacture of bricks and drain tiles. Several important works in this line are found in the broad belt which extends through Huntley, MacNab, Thorbolton and Fitzroy townships, as also in the vicinity of Olivers ferry and Smiths Falls.

Shell-marl. Shell-marl is abundant in the bottoms of some of the lakes, but often too far removed from points of shipment to be of much value except locally. As a fertilizer it is very rarely employed by the farmers of the districts where it occurs. Among lakes which contain this material in quantity may be mentioned White lake in the south part of McNab, Mink lake in Wilberforce, Otter lake in South Elmsley and several lakes in Brougham and Matawatchan. Little attention has however, been directed to these deposits, though the manufacture of hydraulic cement, in which this material is now largely used, may serve to make some of them valuable in the near future.

In the township of Lavant, lot 13, range IV, a deposit of marl also occurs said to cover six acres and having a depth of about seven feet.

BISMUTHINITE.

Bismuthinite. The mineral bismuthinite is known to occur in some part of the township of Lyndoch in small quantities, but the exact location of the deposit has not yet been disclosed. It has also been found in a quartz

vein in small quantity on lot 33 in the south-west range, Clarendon, and on a lot to the north of Buckshot lake, in Miller, but no details of these are to hand

NICKEL.

This mineral has been found in connection with pyrrhotite in the Nickel township of Dalhousie. The occurrence is on lot 18, range III, where a considerable deposit of the latter mineral occurs in a large mass of dioritic rock associated with granite which cuts gray gneiss and limestone. The analysis of the pyrrhotite gave 0.165 per cent nickel with a trace of cobalt, and another deposit on the east half of the same lot gave 0.09 per cent of nickel. The amount of nickel at this place would appear to be too small for economic extraction, and the remoteness from lines of railway is also against the present profitable development of the property.

PEAT.

Although peat-bogs are found at a number of points in the area, many of these have not as yet been tested as to depth or quality of the material. Among those most conveniently situated for exploitation may be mentioned a bog on lots 5, 6 and 7, ranges VI and VII, Beckwith township, which has been sounded to a depth of over thirty feet. It is in places only one mile distant from the Canadian Pacific railway.

Two other bogs also occur in this township one on lots 17, 18 and 19, along the road between ranges III and IV, with a proved depth of from four to seven feet. This is four miles and a half from the line of the Canadian Pacific railway, and the other is found on lot 15, range VI, of the same township.

A large bog occurs in Huntley township, extending over lots 1 to 10, on ranges IX and X, and crossed by the road south from Huntley post-office to the line of Ramsay. The depth of the deposit has been proved at a number of points and found to range from eight to fifteen feet where no bottom was reached. The latter depth is found on the middle of range IX and in the north half of range X. This deposit is in places underlain by white marl.

In Goulbourn township south of the village of Richmond, a large bog also occurs, which extends into the township of Marlborough. The depth of the deposit has not yet been proved.

GLACIAL GEOLOGY.

Glacial
geology.

Indications of ice-action and of subsequent submergence are visible at many places throughout the area embraced in the map sheet. Glacial striæ are frequent and show great divergence in direction, and there are large areas of clay and sand in which marine shells are occasionally found, though their presence is much less frequent than in the district nearer the St. Lawrence and the lower Ottawa rivers.

Lists of all observed striæ have been prepared and are here appended. The course of these tend to show that possibly there were several periods of ice movement and that they were sometimes caused by floating ice as well as by the action of glaciers. Occasionally widely diverging striæ are seen on the same exposure.

Gravel ridges. Ridges of gravel and boulders were noticed at several points. In some of these, notably at the large ridge at Carp station on the Canada Atlantic railway, now, however, mostly removed for ballast, marine shells were very abundant. In other ridges these were not observed. The position of some of the most important of these and their direction are given in the list of striæ. One of the most interesting of these ridges is seen about three miles north of Smiths Falls, near Welsh's siding, where a prominent ridge of gravel crosses the road in a north-east direction. From this locality the bones of a whale were obtained some years ago, the elevation being about 440 feet above sea-level.

Marine shells. In the large area of clay to the west of Renfrew no marine shells have as yet been found. These organisms are apparently for the most part confined to the overlying gravels or in some cases rest upon the rock ridges, the surface deposits having been removed. This is the case on the summit of the ridges south of Sand Point and also on the height of land north of Kinburn. Similar conditions are seen on the crest of the ridge in the south part of Huntley township north of Almonte.

Drift blocks. In places, as along the crest of the Brudenell ridge south of Clear lake, the surface is thickly strewn with large blocks of Black River limestone which now rest upon the crystalline rocks of the mountain range at an elevation of about 600 feet above the limestone deposit which is found in the flat area west of the lake itself. They have probably been derived from this outlier or from the larger area of these rocks which occurs just south of the Bonnechère at Eganville.

The large and prominent ridges of boulders, derived from the crystalline rocks north of the Ottawa, which are so frequent in the area between the lower Ottawa and the St. Lawrence rivers are rarely seen in this portion of the district.

It will be seen that one of the principal ice movements was to the south-east, following the direction of the lower part of the Ottawa river. Going southward however, the prevailing direction is to the south west, following the course of the St. Lawrence river. There is moreover a marked tendency, as the western portion of the area is reached, to assume a more westerly direction, and in some of the striae the course is nearly west. The peculiarity of these changes in direction will be readily seen by reference to the appended list. Further west in rear of Napanee the direction of some of the ice markings is slightly to the north of west. This aspect of the question is more fully considered in the reports by Dr. R. Chalmers, who has carefully examined a large part of this area.

LIST OF STRIAE.

At quarry 2 miles south of Sand Point.....	S. 40 E.
Road Eganville to Clear lake, near brook midway.....	S. 35 W.
Road west of Clear lake, Sebastopol township.....	S. 28 W.
Opeongo road east of Clear lake, near Constance creek.....	S. 25 W.
Opeongo road west from Vanbrugh post-office.....	S. 15 W.
Road from Opeongo road to Hyland lake.....	S. 30 W.
Road from Opeongo road to Eganville, east end of Lake Clear.....	S. 10 W.
Road 2 miles S.W. of Franktown, Beckwith township.....	S. 45 W.
Road 3 miles north of Franktown.....	S. 25 W.
Road Blacks corner to Ashton, at Jock river.....	S. 10 E.
Lots 15 and 16, range XI and XII, Ramsay.....	S. 25 E.
Road Pakenham to Snedden at railway crossing.....	S. 10 E.
Half mile west of Pannure corner.....	S. 60 E.
Half mile south of Perth.....	S. 28 E.
Two miles south of Perth.....	S. 28 E. and S. 32 E.
West of Bathurst sta. C.P.R.....	South, and later S.W.
Three miles north of Smiths Falls.....	S. 1 W. and S. 3 W.
South of Smiths Falls.....	S. 4 E., S. 1 W. and S. 6 W.
One mile north of Smiths Falls.....	S. 46 W.
Half mile south of Perth.....	S. 87 W. and S. 52 W.
Four miles S.W. of Perth.....	S. 42 W.
Two miles south of Perth.....	S. 47 W.
Near Beckwith lake, south of Carleton Junction.....	S.W.
Maberly to Sharbot lake.....	S. 50 W.
Boes of limestone at Sharbot lake.....	S. 55 to S. 45 to S. 35 W.
Road from lake to Zealand post-office.....	S. 35 W., S. 45 W.
Half mile north of Olivers ferry.....	S. 25 W.
Road from Olivers ferry to Perth, half mile from Perth.....	S. 40 W.
First side road south of Olivers ferry.....	S. 25 W.

List of striae

Same road, one mile further on.....	S. 25 W.
One mile N.E. of Port Elmsley.....	S. 10 W.
Near road between Drummond and Elmsley.....	S. 40 W. and S. 25 W.
Two miles east of Port Elmsley.....	S. 5 W.
North Elmsley.....	S. 20 W.
Road north of Perth.....	S. 40 W.
Road south of Lanark.....	S. 35 W.
North of Middleville, near Clyde river crossing.....	S. 5 E.
Crossing of Tay canal, Elmsley.....	S. 35 W. and S. 40 W.
North of Smiths Falls.....	South.
Gravel ridge near Welsh's siding 3 miles north.....	S. 30 W.
One mile N.E. of Smiths Falls, Montague.....	South.
Concessions I, and A. Montague.....	S. 10 E.
Road one mile north of Harper post-office.....	S. 35 W.
Glen Tay or crossing of Tay river.....	S. 40 W.
Road north of Scotch line near Tay river.....	S. 50 W.
Same road south of Bathurst sta. C.P.R.....	S. 48 W. and S. 65 W.
Scotch line road west of Perth.....	S. 40 W.
Half mile N.E. of Perth.....	S. 50 W.
Road north of Lanark.....	South and S. 20 W.
Near Armstrong corner Lanark.....	S. 50 W.
Road south of Fall brook.....	S. 30 W.
One mile north-west of Maberly post-office.....	S. 85 E.
Road crossing Bolton creek, 5 miles west of Fall brook.....	S. 50 W.
Road east of Middleville, Lanark.....	S. 10 E.
East side Robertsons lake, Lavant.....	S. 20 E.
South line of Darling, N. of Galbraith post-office.....	South.
Road half mile N.W. of Dalhousie lake.....	S. 45 W.
Road one mile west of McDonald's corner.....	S. 60 W.
Kan es on road Fall brook to McDonalds corner.....	N. 60 E.
Near Bathurst sta. C.P.R., range IV and V, Bathurst.....	S. 45 W.
Near Dalhousie lake road between VIII and IX.....	S. 45 W.
West of McDonalds corner, lot 9, ranges X and XI.....	S. 50 W.
Lot 17, range I, Bathurst.....	S. 50 W.
Bend of road south of Tay river to Scotch road.....	S. 50 W.
Road between lots 20 and 21, Bathurst 1 mile east.....	S. 10 W.
Quarter mile S.E. of corners on road to Playfair.....	S. 20 W.
Half mile north of Watsons corner.....	S. 10 W.
Near Elliot post-office, east of Christie lake.....	S. 40 W.
Road from Clayton to Lanark, east line of Lanark.....	S. 10 W.
Forks of road one mile west of Poland.....	S. 10 W.
Corner of road south of Joes lake.....	S. 10 E.
Kingston and Pembroke railway near Folger station.....	S. 25 W.
South side Madawaska river on MacNab line.....	S. 25 E.
Road south side Calabogie lake.....	S. 25 E.
Road near Ashdod station, Kingston and Pembroke railway.....	S. 40 E.
Corner of road between Renfrew and Opeongo stations.....	S. 47 E.
Road S.E. of Douglas station, Canada Atlantic railway.....	S. 25 E.
East side Loon lake, Effingham.....	S. 20 W.
Road past Mazinaw lake to Cloyne.....	S. 10 W.
Road near Beech corner four miles west of Plevna.....	S. 5 W.
Addington road near Burnt bridge, Madawaska river.....	South.
Back road south of White lake, Darling township.....	S. 30 E.
Road south of Pakenham, near Indian river.....	S. 5 W.

Pannure corner, Huntley	S. 50 E.
South of Pannure, near Ramsay line	S. 50 E.
Half mile north of Pakenham, on road to Kinburn	S. 30 E.
Three-fourths mile east of Antrim corner	S. 60 E.
South Huntley, north of big fault	S. 50 E.
Cross roads, two miles north of Kinburn	S. 55 E.
One mile north-west of Hazeldean	S. 20 E.
100 yards west of South March station, Canada Atlantic railway	S. 30 E.
Corner of road one mile south of Cloyne	S. 5 W.
Road S.E. of Carleton Place, line VIII. and IX.	Marine shells
Corner of Huntley, Goulbourne, Ramsay township.	Marine shells
Carp station in gravel ridge	Marine shells
Ridge one mile south of Sand Point	Marine shells
Ridge four miles north of Kinburn station	Marine shells
Ridge south part of Huntley township, road to Almonte ...	Marine shells

APPENDIX

Preliminary lists of fossil organic remains from the Potsdam, Beekmantown (Calciferous), Chazy, Black River, Trenton, Utica, and Pleistocene formations comprised within the Perth Sheet (No. 119) in Eastern Ontario.

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INTRODUCTION.

The sedimentary formations comprised within the area of the Perth Sheet (No. 119) have afforded quite a series of fossil organic remains wherever they crop out in those portions of the counties of Carleton, Lanark and Renfrew where collections have been made from time to time by officers of the Geological Survey of Canada, as well as by local geologists and persons interested in the development of the geological resources of this portion of the Ottawa valley.

The palaeontological evidence obtained in these collections indicates the presence of at least six palaeozoic formations. They include the following:—

- The Utica formation
- The Trenton formation
- The Bird's eye and Black River formation
- The Chazy formation
- The Beekmantown (Calciferous) formation
- The Potsdam formation.

Although the Potsdam formation is referred to the Cambrian system in New York State, nevertheless the palaeozoic formations of sedimentary origin comprised within the Perth Sheet all appear to belong to the one system, namely, the Ordovician or Cambro-Silurian system as it is sometimes styled, forming a very continuous and unbroken series of strata from the base of the Potsdam sandstone, as exposed within the area in question, to the bituminous shales of the Utica formation.

From the collections examined by myself as well as from the lists prepared by the late E. Billings—palaeontologist to the Geological Survey in the early days of the department when the first examination and reports were made on the geological resources of this part of Canada, no evidence of truly typical Cambrian strata has been recorded. The presence of othocerata and gasteropoda in the sandstones of the Potsdam formation clearly indicate that the fauna present is not "primordial," but one appertaining to the later and subsequent series, sometimes styled "the second fauna", the Ordovician Age.

With the exception of the two collections from the Clear Lake outlier in the Township of Sebastopool, County of Renfrew, obtained in 1895 and 1896 respectively by Dr. Ells and his assistants, there are practically no systematic palaeontological collections available in the department from which to prepare a satisfactory report on the fauna entombed in the sedimentary strata within the sheet in question. There are however quite a number of smaller collections which have served to identify the geological horizon in various localities. The lists are here given in the natural order of sequence and time from the oldest Potsdam to the most recent Pleistocene formations met with.

ORDOVICIAN SYSTEM.

POTSDAM FORMATION.

I. Perth, Ontario. Collected by Sir W. E. Logan and Dr. James Wilson.

In the neighbourhood of Perth, the formation consists of white sandstone displaying tracks or trails of marine organisms referred to *Protichnites* and *Climactichnites*. Two forms have been noticed on the slabs of sandstone as follows:—

1. *Protichnites*. *sp.* a form allied to *P. septem-notatus*, Owen.
2. *Climactichnites Wilsoni*, Logan.

The type specimen from which Sir Wm. Logan described the so-called ladder-tracks referred to as *Climactichnites* is now preserved in the Museum of the Geological Survey and exhibited on the west wall of the palaeontological hall. An excellent woodcut or illustration of *Climactichnites Wilsoni*, Logan may be seen on page 107, Chapter VI of the "Geology of Canada" 1863.

It was in a quarry and on the property of Mr. Glen, lot 6, Range III, in the Township of Drummond, near the town of Perth, Ont., that the late Dr. James Wilson discovered these trails and tracks of marine organisms.

II. Lot 22, Range IX. Township of Bastard, North of Beverly, Ont.

The following species are recorded by E. Billings from the sandstones of this formation there exposed.*

Although they are not numerous, nevertheless, these forms serve well to ascertain the geological horizon to which the strata holding them belong

1. *Fucoids*.
2. *Scolithus Canadensis*, Billings.
3. *Lingula acuminata*, now known as *Lingulepis acuminatus*, Conrad.

III. Perth, Ontario.

1. *Scolithus Morrisi*, Dawson.‡

In 1898 Mr. E. D. Ingall, of the Mines Branch of the Geological Survey Department brought to the museum of the office a fine example of the species figured by Sir Wm. Dawson in the Quarterly Journal of the Geological Society of London.† Vol. 46, p. 603.

This specimen was presented to the survey by R. J. Drummond Esq. of Perth and was obtained by him from the sandstone quarry from which the blocks were used for canal purposes.

POTSDAM-BRECKMANTOWN.

(*Passage Beds*)

IV. Smiths Falls, Ont.

During the excavations for the aqueduct along the streets of Smith's Falls, in 1901, brownish-yellow and white more or less saccharoidal sandstone layers were blasted and among the fossil remains collected by the writer were the following:—

1. *Fucoids*.
2. *Ophileta complanata*, Vanuxem (several specimens).

* Geol. of Can., 1863, page 93.

† Quart. Journ. Geol. Soc. Vol. xlvi, pp. 515-517, fig. 7. London.

‡ A fine example of this species of *Scolithus* from Perth, exhibited in the cases of the Geological Department in the Peter Redpath Museum of McGill University, Montreal, bears the designation. *Scolithus Morrisi*, Dawson.

The strata holding these may fairly be described as passage beds between the Potsdam formation and the next overlying series: the Beekmantown formations. The thin-bedded and arenaceous character of the strata in which the fossil remains are obtained, indicate that the littoral or shallow—water and sandstone—depositing conditions of the Potsdam had not disappeared whilst the organisms themselves are characteristic of the dolomites or calciferous sandstone of the Beekmantown formation.

CHAZY FORMATION.

V. Township of Huntley, Ont.

(a) In yellowish-white sandstone in the lower part with a gray limestone above, in which there is an interstratified bed of blackish-brown limestone crowded with bivalve Entomostraca not far above which are several feet of yellowish-gray, buff-weathering argillaceous magnesian limestone applicable for the purpose of hydraulic cement, the following species occur: *

1. *Strophomena alternata*, Conrad.
2. *Rhynchonella plena*, Hall.
3. *Leperditia Canadensis*, Jones.
4. *Bathyurus Angelini*, Billings.

The *Rhynchonella plena*, so characteristic of the Upper Chazy is stated to be very rare. It is now referable to the genus *Camarotochia*.

(b) On lot 6, Range X. township of Huntley near Pakenham, the following species of ostracod occurs in a brownish-black limestone in great abundance.

1. *Leperditia Canadensis*, Jones.

BLACK RIVER FORMATION.

VI. Pakenham, Ontario, near Dicksons Mills.

1. *Columnaria Halli*, Nicholson.
2. *Orthoceras fusiforme*, Hall.
3. *Actinoceras Bigsbyi*, Stokes.

Of the fossil evidence obtained here, Mr. Billings writes:—

"The Birdseye and Black River formation yields very large masses of *Columnaria alveolata* and some of its beds abound with great

* Geol. of Can. 1843, p. 128.

+ Geol. of Can. 1843, p. 173.

orthoceratites, the chambers of which have occasionally been found by Mr. Dickson to hold large quantities of petroleum" " Among the orthoceratites at Dicksons Mills *Orthoceras Bigsbyi* ranges from nine to eighteen inches in length, and *O. fusiforme* is met with two feet long."

VII. Pakenham, Ontario. Collection of the late Sheriff Dickson.

1. *Bythotrephis* (*Chondrites*) *succulens*, Hall.
2. *Stromatocerium rugosum*, Hall.
3. *Tetradium fibratum*, Safford.
4. *Columnaria Halli*, Nicholson.
5. *Orthis tricenaria*, Conrad.
6. *Actinoceras Bigsbyi*, Stokes.

VIII. Township of McNab. Collection received from A. M. Campbell, Esq. December 10, 1890.

1. *Streptelasma profundum*, Hall.
2. *Columnaria Halli*, Nicholson.
3. *Murchisonia* (*Hormotoma*) *gracilis*, Hall.
4. *Murchisonia* (*Lophospira*) *Milleri*, Hall.
(= *M. bicincta*, Hall of former reports.)
5. *Murchisonia* or *Loxonemao* sp.
6. *Trochonema umbilicatum*, Hall.

TRENTON FORMATION.

IX. Pakenham, Ontario, from the collection of the late Sheriff Dickson, 1890.

1. *Licrophycus minor*, Billings.
2. *Solenopora compacta*, Billings.
3. *Prasopora oculata*, Foord.
4. *Prasopora lycoperdon*, Vanuxem. (= *P. Selwyni*, Nich.)
5. *Agelacrinites Dicksoni*, Billings.
6. *Glyptocrinus ramulosus*, Billings.
7. *Pleurocystites squamosus*, Billings.
8. *Lingula quadrata*, Eichwald, as of Billings.
9. *Lingula riciniiformis*, Hall.
10. *Plectambonites sericeus*, Sowerby.
11. *Rafinesquina alternata* (Conrad), Emmons.
12. *Rafinesquina deltoidea*, Conrad.
13. *Dalmanella testudinaria*, Dalman.
14. *Murchisonia bellicincta*, Hall.

15. *Fusispira subfusiformis*? Hall.
16. *Orthoceras* sp.
17. *Endoceras proliiforme*, Hall.
18. *Asaphus platycephalus*, Stokes.
19. *Calymene senaria*, Conrad.
20. *Ceraurus pleurexanthemus*, Green.

X, Locality:—"One mile north of Hotel, Almonte, Ont." Collector and date:—T. C. Weston, 1866.

Horizon:—Near the summit of the Trenton formation, so far as the association of forms in the small collection examined appears to indicate.

List of species.

Bryozoa,

1. *Pachydictya acuta*, Hall.

Brachiopoda.

2. *Leptaena* (*Plectambonites*) *sericea*, Sowerby.
3. *Orthis* (*Dalmanella*) *testudinaria*, Dalman.
4. *Zygospira modesta*, Hall.

Cephalopodia.

5. *Orthoceras strigatum*, Hall.

Trilobita.

6. *Proetus parviusculus*, Hall, or a very closely related form.
7. Portion of the cephalic shield and pygidium of an asaphoid or proetid trilobite, too imperfectly preserved for identification. The larger fragment of the pygidium present in the collection resembles somewhat the flattened pygidium of *Bathyurus extans*, Hall, of Black River age, whilst it presents also affinities to *Ptychopyge*. Until better specimens are procured, it will be impossible to state definitely what the species is that is here represented.

Ostracoda.

8. *Primitia*, sp. nov., a rather large and apparently undescribed form from the Ordovician of the Ottawa valley

UTICA FORMATION.

XI. Clear Lake outlier, Clear lake, south-western corner of Renfrew county, Ontario.

Collected by R. W. Ellis and L. M. Lambe, 1896. Horizon,--Lower Utica.

List of species.

Graptolitoidea.

1. *Orthograptus quadrimacronatus*, Hall.

Echinodermata.

2. *Crinoidal fragments*.

Brachiopoda.

3. *Leptobolus insignis*, Hall.
4. *Leptobolus*, sp. indt.
5. *Lingula Progne*, Billings.
6. *Lingula curta*, Hall.
7. ? *Schizocrania filosa*, Hall.
8. *Plectambonites sericeus*, Sowerby. Three varieties such as are also found in the lower Utica of Gloucester and Ottawa.
9. *Orthis (Dalmanella) testudinaria*, Dalman. A rather small and depauperated variety.
10. *Zygosprya modesta*, Say.

Gasteropoda.

11. *Pleurotomaria* or *Murchisonia*, sp. Too imperfectly preserved for identification.

Lamellibranchiata.

12. *Lyrodesma pulchellum*, Hall.
13. *Modiolopsis curta*, Hall.
14. *Nuculites*, sp.
15. ? *Pterinea*, sp. indt.

Cephalopoda.

16. *Endoceras proteiforme*, Hall. Embryo sheaths.
17. *Orthoceras lamellosum*, Hall.
18. *Trocholites ammonius*, Emmons.

Pteropoda.

19. *Conularia gracilis*, Hall.

Trilobita.

20. *Triarthrus Becki*, Green.
21. *Asaphus latimarginatus*, Hall. (= *Asaphus Canadensis*, Chapman).

Ostracoda.

- 22.
- Primitia Ulrichi*
- , Jones.

Cirripedia.

- 23.
- Turrilepas Canadensis*
- , Woodward.

Note on the fauna.

The assemblage of species noted above and identified from the collection before me, represents that of the lower half of the Utica formation. It corresponds to the fauna of the same horizon found along the Rideau river below Sparks rapids and above Cummings Bridge. Among the more interesting forms discovered were:—*

Turrilepas Canadensis, Woodward. This small cirripede was first found by the writer in the impure bituminous limestone band at the head of Sparks rapids on the Rideau river, which also marks the zone of *Schizambon Canadensis*, that pretty little brachiopod formerly referred to as *Siphonotreta Scotia*, Davidson.

Conularia gracilis, Hall. A number of examples or fragments of this species appears in this collection, as indeed they do in almost every collection from this formation, from the Manitoulin islands, Lake Huron, from Ontario and Quebec, even as far north as the Lake St. John, outlier, where well-preserved examples of this interesting sessile *Conularia* were obtained by the late Dr. A. R. C. Selwyn in 1870.

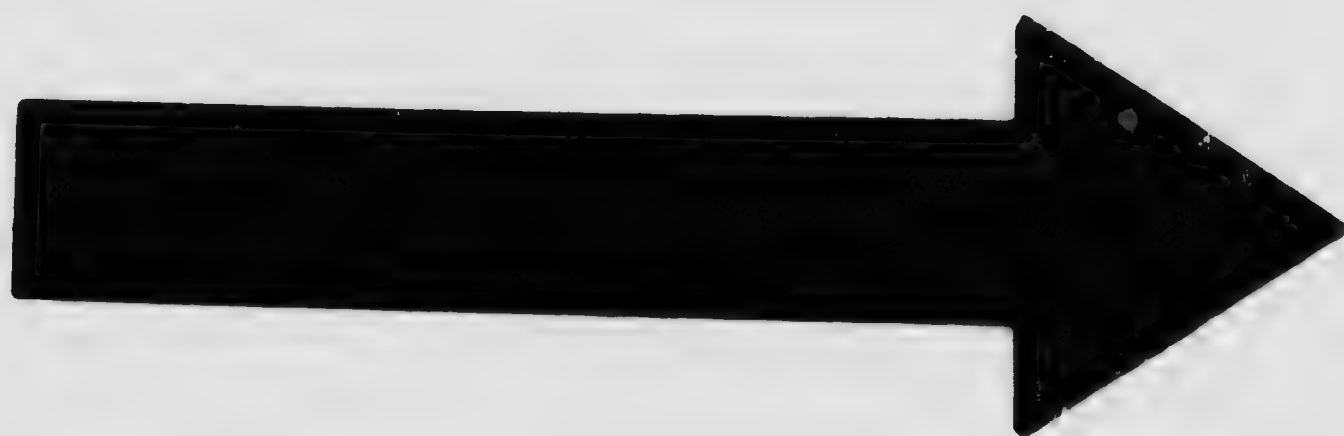
For further information on this species the reader is referred to that most interesting paper by Dr. R. Ruedemann entitled:—The "Discovery of a Sessile *Conularia*."†

- XII. Fossils from Clear lake, Township of Sebastopool, County of Renfrew, Ont. collected by W. J. Wilson, 1895, for Dr. R. W. Ellis.

1. *Clinacograptus*, sp.
2. *Crinoidal* fragments.
3. *Lingula Progne*, Billings.
4. *Lingula curta* † Hall.
5. *Leptobolus insignis*, Hall.
6. *Leptobolus* sp.
7. *Plectambonites sericeus*, Sowerby.
8. *Orthis (Dalmanella) testudinaria*, Dalman.
9. *Zygospira modesta*, Say.

* Geological Magazine, Dec. III. Vol. VI, no. 300, p. 271, 1889.

† Amer. Geol., Vol. 17. No. 3, pp. 158-165. March 1896. Minneapolis, Minn.



10. *Trocholites ammonius*, Emmons.
11. *Endoceras proteiforme* (?) Hall.
12. *Conularia gracilis*, Hall.
13. *Tiarthrus Becki*, Green, adult and larval forms.
14. *Asaphus latimarginatus*, Hall (= *Asaphus Canadensis*, Chapman).
15. *Primitia Ulrichi*, Jones.

It was from this collection by Mr. Wilson, that the *Utica* formation was recorded so far west of Ottawa city, along the Ottawa valley.

SAXICAVA SAND.

XIII. Carp. Ont. Collected by H. M. Ami and W. J. Wilson, September, 26th, 1896.

In the sands and gravels overlying the clays of the valley of the Mississippi river, forming the ballast pit near the Railway Station at Carp, the following species of marine shells were found* :—

1. *Saxicava rugosa*, Linnaeus.
2. *Macoma Balthica*, L. (= *M. fragilis*, Fabricius of previous lists.)
3. *Balanus Hameri*, Ascanius.
4. *Balanus crenatus*, Bruguière.

Immediately south of the Canada Atlantic and Parry Sound Railway Station at Carp, the hill, some twenty five feet in height, consisting of coarse gravel, admirably suited for ballast and made up for the most part of well-worn, and rounded sea-washed pebbles of Archæan age, was utilised by the railway authorities, and practically carried away in its entirety.

Collected by W. J. Wilson & H.M.Ami, Sept 26th, 1896.

XIV. Mohrs corners P.O. Collected by W. J. Wilson and H. M. Ami, September, 26th, 1896.

On the brow of the hill, and three-quarters of a mile to the south-east of Galetta Station along the Canada Atlantic and Parry Sound Railway, forming a sand and clay terrace, the following marine shells were found by Mr. W. J. Wilson and the writer, and recorded in the October number of the *Ottawa Naturalist* for 1896.*

1. *Saxicava rugosa*, L.
2. *Macoma Balthica*, L.

* The *Ottawa Naturalist*, Vol. x., No. 7, p. 142, Oct. 1896.

QUATERNARY SYSTEM.

PLEISTOCENE.

(Shell-Marl or lacustrine deposit)

XV. Lake Clear, Township of Sebastopol, Renfrew Co., Ontario.

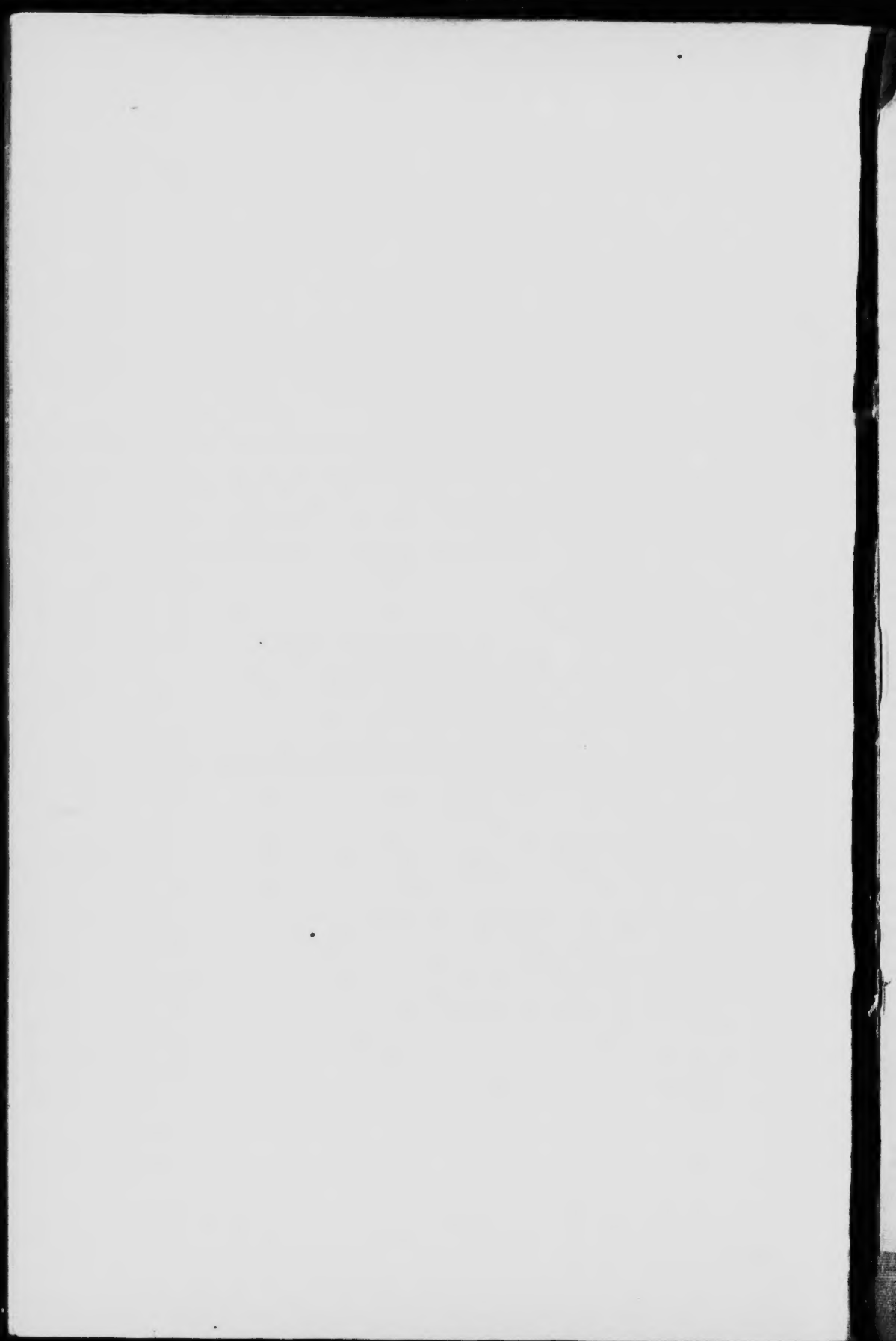
In Report of Progress of the Geological Survey of Canada for 1857, Mr. E. Billings, who visited the locality, states that in the smaller lakes north of and connected with Lake Clear he "found that extensive deposits of shell-marl were in the progress of accumulation."

From these deposits he found the following species :—

1. *Physa heterostropha*, Say.
2. *Planorbis campanulatus*, Say.
3. *Planorbis bicarinatus*, Rackett.
4. *Paludina decisa*, Say.
5. *Cyclas orbicularis*, Say.
6. *Unio complanatus*, Lea.
7. *Anodon fluviatilis*, Lea.

Mr. Billings adds the following interesting note :—"The marl however consists almost altogether of the shells of the species of Gastropoda above mentioned and as the living specimens do not appear to be more numerous in the lake than they are upon the shores of some of the rivers of the country, it must have required a great length of time for these remains to accumulate to the depth of several feet, which is often attained by the beds of marl."

* Ottawa Naturalist, Vol. X, No. 7, p. 143, 1896



Explanation of Colours and Signs

Quaternary Deposits

D1a

D1b

D2a

D2b

D2a

D1b

D1a

Archaeology

A

A

A



PROVINCE OF
Parts of Counties of
Lennox and Addington, Frontenac, and Perth Shires

Natural Scale

Scale 4 miles

To accompany

R. W. BELL, D.Sc.

North Street, N^o 11.

Natural Scale

Scale, 4 miles to

Table 1

Fig. 1. The effect of the concentration of the solution of the initiator on the rate of polymerization of α -methylstyrene in the presence of Cu^{2+} ions.

WELLS, J. D. C.

(100)

Sources of Information

Surveys by the [redacted] at Survey staff; and official
plans of surveys [redacted] Crown Lands Department of
[redacted]

Journal of Management Studies 2000, 33(1), 1-12

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